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# Montana Energy Conservation Study of State Owned Buildings

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Prepared by
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Great Falls—Missoula

January 1979

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STATE OF MONTANA
DEPARTMENT OF ADMINISTRATION
DIVISION OF ARCHITECTURE & ENGINEERING
CAPITOL BUILDING, HELENA, MONTANA 59601

RECEIVED
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January 16, 1980

Re: Energy Conservation Study
Mont A/E 77-30-04A

Gentlemen:

First of all, I would like to thank everyone for their excellent cooperation with both my office and Drapes Engineering regarding the Statewide Energy Conservation Study. I appreciate the patience you have all displayed during the last two years for a project that, because of it's sheer magnitude, seems to move slowly at times, if at all. I assure you that I am most cogizant of the skyrocketing energy costs facing you and that no one is more anxious than myself to complete this energy retrofit program as quickly as possible. I personally feel that the legislature will continue it's support and that the program's momentum will "snowball" in the future.

Since the initial appropriation of $200,000 was authorized to conduct a comprehensive energy study, we have organized two presentations to explain the program, both it's goals and it's progress. These meetings where held in Helena and many of you attended one, or both. As you may recall at our first meeting in the fall of 1977 we requested each agency to submit a priority list of buildings to be considered on it's particular campus. The list indicated whether or not the building was metered (gas, condensate, electrical, etc.) and the approximate gross square feet. The individual priority lists were used to compile a Statewide plan for building metering as well as to establish an overall priority program for life cycle analysis. This work has been completed and we are now in the process of beginning the actual retrofit of those buildings that have been audited.

Obviously, the initial appropriation did not provide sufficient funding for all the metering or individual building analysis required throughout the State. Therefore, we have dedicated $175,000 out of the recent $1,000,000 retrofit appropriation to continue work in these areas. In order that we may proceed with Phase II of the program, I would ask that you review your original priority list and either confirm the original list or make the appropriate changes, forwarding the information to my office. It is critical to the project schedule that you submit your lists by January 28, 1980.

To assist you in updating your lists I have attached Appendix 2 from the Drapes Report which includes all buildings metered under the initial phase of the program. Keep in mind that some buildings had no existing monitoring and required metering of all the utilities while others already had partial metering and required lesser degrees of work. With the meters installed to date, however, all the buildings in Appendix 2 should have complete metering systems for use in future monitoring.

Through the course of Phase I, numerous problems associated with a project of this size have surfaced and subsequently been solved. The one area that does seem to need more clarification concerns the question of specific responsibilities. Basically, the project is no different than any other State construction job. This office, the consultant, and the individual agency all have roles to play. As with all projects, the Architecture and Engineering Division performs the necessary construction administration and works with the agencies to determine desired program parameters. The consultant provides technical expertise to the Owner and has primary responsibility for job related items, such as the verification that the Owner "got what he paid for". And finally, each agency has the responsibility to maintain systems and/or facilities after original warranty periods have expired. For example, the meters that have been installed on the campuses are really no different than the addition of a new building. In each case the individual agency assumes the responsibility of maintaining the facilities provided in the construction project and budgets accordingly.

In several instances condensate meters were found to be defective, and had to be replaced. In other cases, however, the meters became inoperable after awhile because of leaking traps, which is clearly a maintenance item for which the supplier is not responsible. I realize that we are quite susceptible to this condition while we are working with older buildings throughout the State, but it is the only way to confirm projected energy savings resulting from retrofit. We are hoping to eliminate this problem in the future by including metering in all new construction projects.

Again, I thank you for your excellent cooperation to date and I remind you of the priority list submittal schedule mentioned earlier. Working together we can truly make Montana an energy efficient State.

Sincerely,

PHILIP H. HAUCK, AIA, Administrator
Architecture & Engineering Division

PHH/lmv
attachement

P.S. I am planning on organizing a meeting in Helena sometime in March which will update everyone on the status of the energy program.

## APPENDIX 2

BUILDINGS METERED BY DRAPES ENGINEERING
UNDER THE A/E 77-30-04 PROJECT

BOULDER RIVER SCHOOL AND HOSPITAL

Boys Dormitory #7
Cottage #3
Cottage #5
Girls Dormitory #6

CAPITOL COMPLEX

Agriculture
Board of Health
Boiler Plant
Capitol Building
Cogswell Building
Livestock Annex
New Mitchell Building
Old Mitchell Building
Veterans Memorial Building

EASTERN MONTANA COLLEGE

Liberal Arts
Library Building
McMullen Hall
Special Education

EASTMONT TRAINING CENTER

Multipurpose Center

GALEN

Annex Hospital
Kitchen, Crockett, and Terrill Wing
Receiving Hospital

MONTANA STATE PRISON

Maximum Security
Rothe Hall
Slaughter House

MONTANA STATE UNIVERSITY

Cooley Lab
Culbertson
Gaines Hall
Health Center
Health & Physical Education Building

MONTANA STATE UNIVERSITY (CONT'D)

Heating Plant
Horticulture
McCall Hall
Pryor
Ryan Lab
Sherrick
Stadium
Student Union

MONTANA TECH

Library - Museum
Men's Residence Hall
Metallurgy

MONTANA VETERAN'S HOME

New Veteran's and Nursing Building

MOUNTAIN VIEW SCHOOL FOR GIRLS

Maple Cottage

NORTHERN MONTANA COLLEGE

Auto Mechanics
Cowan Hall
Gym Armory

PINE HILLS SCHOOL

Academic Training
Physical Training

SCHOOL FOR THE DEAF AND BLIND

Academic Facility

SWAN RIVER YOUTH CAMP

Food Service
Lodge

UNIVERSITY OF MONTANA

- Business Administration Building
- Chemistry - Pharmacy
- Fine Arts
- Forestry
- Health Science
- Journalism
- Liberal Arts
- Main Hall
- Mathematics
- Mens Gym
- Music
- Natural Science
- Natural Science Addition
- Psychology
- Venture Center
- Womens Center

WARM SPRINGS STATE HOSPITAL

- Bolton
- Receiving Hospital
- Warren

WESTERN MONTANA COLLEGE

- Auditorium and Shop
- Gymnasium
- Main Building
- Old Library
- Physical Education Building
- Student Union

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SECTION: 1. ABSTRACT

In compliance with the Montana A/E 77-30-04 project Drapes Engineering has:

1. Published and distributed to all major building physical plant administrators an Energy Conservation Guideline For State-Owned Buildings Booklet (Ref. App. 1 this report).
2. Installed energy meters on 75 state-owned buildings (Ref. App. 2 this report).
3. Completed a building energy audit of 97 state-owned buildings (Ref. Section 5 this report).
4. Surveyed 20 state-owned buildings for energy conservation using a life cycle analysis evaluation (Ref. Section 7 this report).
5. Compiled and analyzed 17 state-owned building complexes for a 5-year energy audit (Ref. Section 3 and App. 5 this report).
6. Submitted a plan (Ref. Section 4 this report) for the State of Montana to effect energy conservation and reduce life cycle costs in state-owned buildings. The proposed plan is comprised of five stages:
   a. An education and awareness program
   b. An energy metering program of state-owned buildings
   c. An energy auditing and monitoring program of state-owned buildings
   d. Survey buildings using life cycle analysis evaluations to determine economically feasible energy saving options
   e. Retrofit or installation of economically feasible energy saving options

SECTION: 2. INTRODUCTION

An Energy Conservation program was conceived by the 1977 Legislature to reduce building energy consumption and energy costs of state-owned buildings. This is the final report of the initial phase of this proposed long-term program.

In what has become a rude awakening, fossil fuel energy, in its various forms, is a depleting resource; and in following basic economic laws of supply and demand, energy costs have risen dramatically over the past few years. As energy costs have risen, the consumer, i.e. the private individual, the businessman, and government, have initiated energy cost reduction programs. In terms of government, energy cost reduction programs have been implemented from the smallest governmental unit up through the federal government. Consequently, the State of Montana under the auspices of the Department of Administration, Architecture and Engineering Division has embarked upon an energy conservation program for state-owned buildings.

The following report summarizes the efforts of state government to date, and presents a recommended energy conservation program for state-owned buildings to further reduce energy consumption and lower life cycle costs.

Section 3 of this report analyzes a major portion of the state-owned buildings for effects of past energy conservation measures. Section 4 presents the recommended building energy conservation program for the State of Montana. Section 5 is a computerized building energy audit for buildings with energy consumption data for 1977. Section 6 is an explanation of the economic analysis that was performed on the 20 surveyed buildings, and Section 7 enumerates the results of the twenty buildings surveyed for energy conserving options.

A commitment to energy conservation by continued investment of tax dollars for energy conservation in state-owned buildings is becoming a necessity for state government in Montana. Higher energy costs will place unreasonable future

demands on the taxpayers of Montana. Consequently, a program to reduce energy consumption should be undertaken not only for a demonstration of energy conservation, but also to demonstrate the economic prudence of saving energy which results in a net savings of Montanan's tax dollars.

SECTION: 3. ENERGY CONSERVATION MEASURES TO DATE

To determine where an energy conservation program for state-owned buildings must start, program planners need to know where and how building energy is used in state-owned buildings.

At present only small amounts of reliable information exists as to how much energy is used to maintain individual building environmental conditions in state-owned buildings in Montana. Consequently, the State of Montana has initiated a building energy consumption data gathering network. For the most part, however, the available energy consumption data is for multiple building complexes instead of individual buildings (Ref. Section 5 for available building audit). Nevertheless, using the available historic energy usage data, an energy audit can be performed on 17 major state-owned building complexes. From this audit, a history of energy consumption in state-owned buildings can be used to determine if any significant energy conservation has been accomplished to date. This history can then provide a base upon which future decisions for furthering energy conservation can be made.

After deciding to compile an energy audit of 17 building complexes, several normalizing and data reducing techniques have to be used in order to be able to compare energy consumption of buildings for different locations, different sizes, and for different years. First the available data is consumption for fuel and electricity for each building complex either for a calendar year or for a fiscal year. For consistency (and other reasons explained later), data has been converted to a calendar year. Next a common unit of energy, the British thermal unit (BTU), is used to reduce the various energy types and fuels into common units. Since the audit is concerned with only energy available to the building complex, no resource utilization factor which accounts for the energy conversion efficiencies and transportation losses (Ref. Section 4) are included in converting the energy to a common unit.

To include the capability of comparing one building's energy usage with another's usage requires two additional normalizing factors. First is the industry standard of basing consumption on an annual energy unit per total building floor area, thus enabling comparisons between large buildings and small buildings on a common basis. This index, with units of BTU per gross square feet per year (BTU/GSF-YR), is fairly reliable for comparing building complexes or individual buildings that do not experience significant annual weather changes or locational climatic differences. To compensate for these weather variations for different locations and/or different years, a normalizing factor relating a building's energy consumption to the building's external environment must be used.

The heating degree day (DD) index which is directly related to a building's heating energy consumption, is calculated by the National Weather Service on a calendar year basis for over 200 locations in Montana. This index is a measure of how cold one location is in comparison to another. The index can therefore be used to compare energy consumption of buildings in different locations or the same building for different years. Thus a final energy usage index (EUI) with units of BTU per gross square feet per degree day (BTU/GSF-DD) is used to make comparisons of building energy consumption.

As with any index, there are some deficiencies, but optimum usage of an index results when these deficiencies are recognized. The heating degree day index is based on assuming a certain amount of internal building heat gain, i.e. lights, computers, motors, etc., that help offset the building heat loss. Consequently, building groups which perform different functions, such as hospitals or warehouses, should not be compared against each other. Another drawback is that the heating degree day index does not take into consideration the amount of energy in the total annual energy consumption that is used for cooling.

However, previous studies on buildings in Montana have shown that energy required for cooling is less than 10% of the total annual energy usage for most buildings with mechanical cooling systems. Although there are deficiencies with the heating degree day index, the relative stability that it provides for an energy auditing program far outweigh the disadvantages of not including it.

The table in Figure 3.1 is the 1977 energy audit for the 17 complexes for which data is available listed in decreasing value of the energy usage index (EUI). From this table, it is obvious that building groups are ordered by functional types. Hospitals with their 24-hour occupancy, requirements for large volumes of fresh air, and large domestic hot water loads, generally show up as the biggest energy users. Next in order are apartment complexes that require 24-hour occupancy, normal rates of ventilation and moderate domestic hot water loads. Next in order are schools, of which only a portion of the buildings are devoted to 24-hour occupancy. The office buildings are the lowest group of energy consumers because the number of full usage hours is also the lowest.

Further analysis of the building complex audit reveals more clearly the areas where energy is used. Figure 3.2 shows a breakdown of energy types by building complex type (due to questionable data, Ref. Figure 3.4, Swan River Youth Camp is deleted from further analysis). As previously indicated in Figure 3.1, the highest total energy user is the hospital group and the lowest total energy user is the office group. The consumption trend is the same when comparing annual natural gas consumption from one building group to the next as when comparing the total energy use.

For a relative comparison, electrical consumption is given in the same units as the natural gas consumption although a relatively large portion of the

STATE BUILDING COMPLEX ENERGY CONSUMPTION - 1977

| Complex | Predominate Building Usage | EUI BTU/GSF-DD |
|---|---|---|
| Warm Springs | Hospital | 38.46 |
| Swan River Youth Camp | Misc. | 37.44 |
| Boulder River School & Hospital | Hospital | 36.56 |
| Galen | Hospital | 31.68 |
| Veterans Home | Apt. Complex | 27.46 |
| Home for the Aged | Apt. Complex | 27.13 |
| Pine Hills School for Boys | School | 25.73 |
| Montana State University | School | 23.22 |
| Eastern Montana College | School | 20.35 |
| Eastmont Center | School | 20.29 |
| University of Montana | School | 17.19 |
| Mountain View School for Girls | School | 17.11 |
| Northern Montana College | School | 16.57 |
| Western Montana College | School | 16.39 |
| School for the Deaf & Blind | School | 15.91 |
| Montana Tech | School | 14.21 |
| Capitol | Office | 12.99 |
| All Buildings | | 23.97 |

Figure 3.1

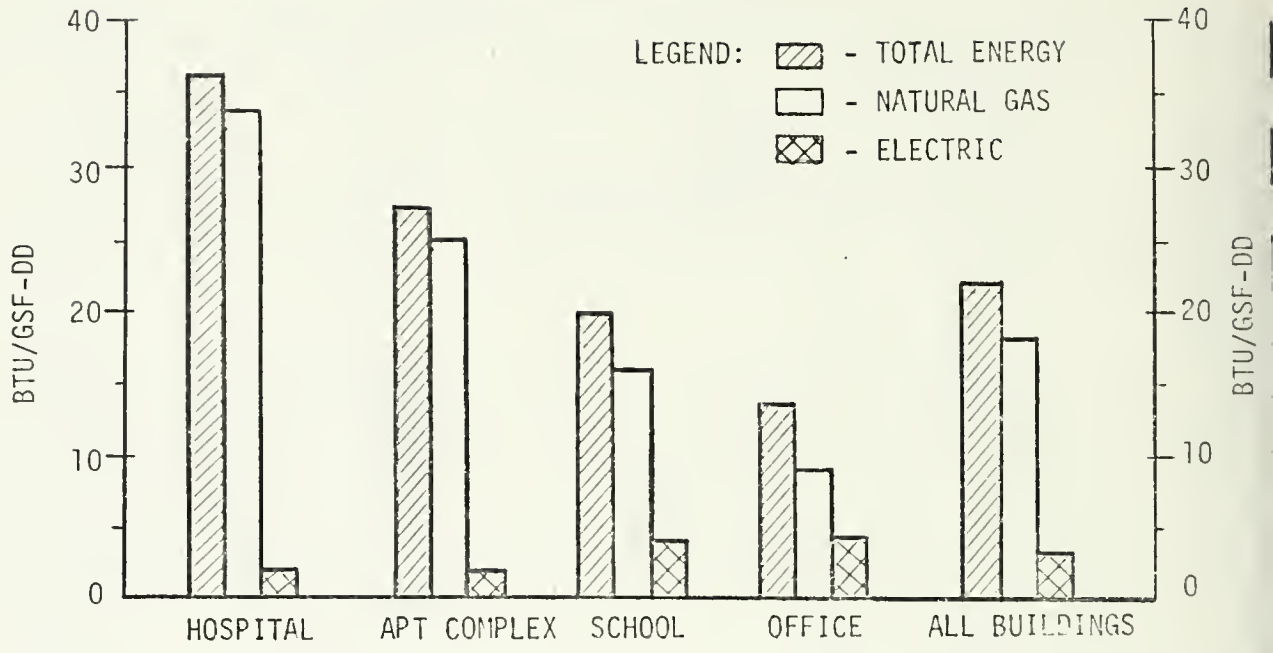



FIGURE 3.2 RELATIVE USAGE OF ENERGY BY BUILDING TYPE

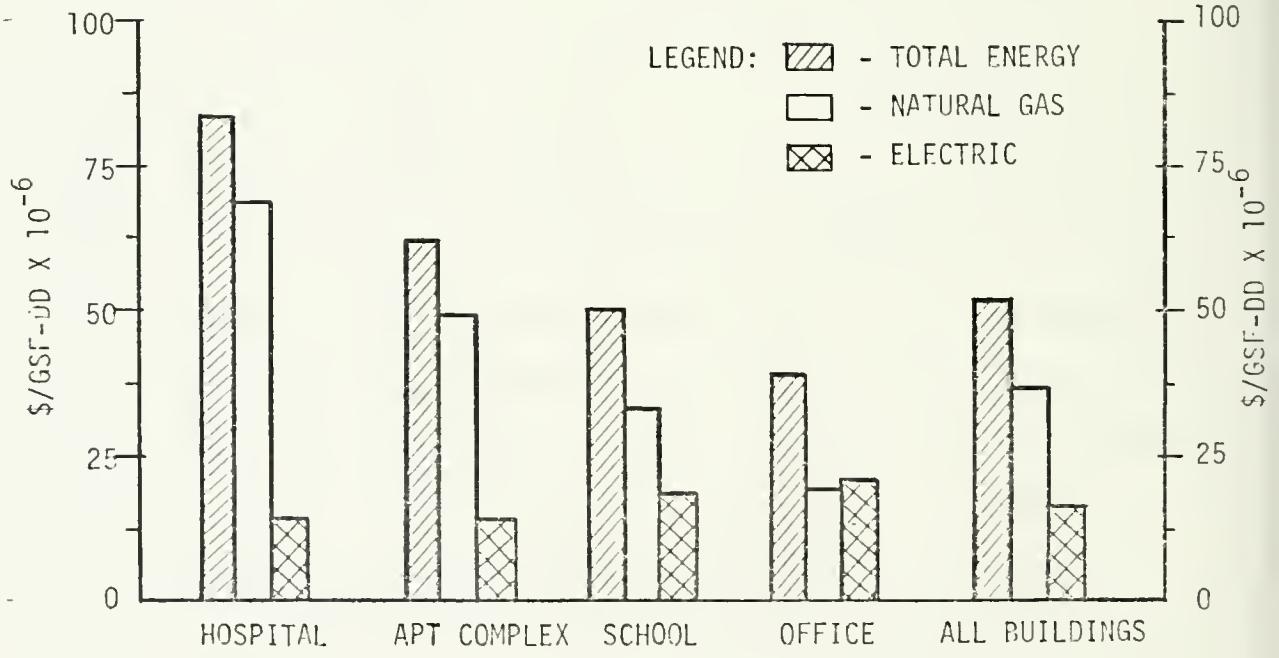



FIGURE 3.3 RELATIVE COSTS OF ENERGY BY BUILDING TYPE

electrical consumption doesn't generally follow a degree day trend. This analysis indicates that electrical consumption increases as the building occupancy duration decreases. This increase is probably due to higher lighting levels, great usage of office equipment and a greater usage of electrical cooling for school and office type buildings.

In terms of energy cost, Figure 3.3 shows the relative energy costs for operating a square foot of floor space for a degree day ($/GSF-DD). Again the trends noted from Figure 3.2 are apparent in terms of cost for Figure 3.3. However, another conclusion that can be noted is that electrical energy costs are a greater portion of the total energy costs than electrical energy consumption is of the total energy consumption. The higher cost of electricity on a per unit of energy basis, than natural gas, is the reason for this trend. In the case of office buildings, electrical energy costs exceed the natural gas energy costs.

Using an EUI of BTU/GSF-DD, the table in Figure 3.4 is derived from a 5-year building complex audit (Ref. Appendix 5). The table lists the building complexes in decreasing order of percent energy reduction from 1973 to 1977. 1973 was picked as a base year because prior to 1973 and the Arab oil embargo, energy conservation was not a high priority in state-owned buildings. In terms of energy reduction, the school complexes generally show the greatest reductions. Reasons for this trend can possibly be attributed to a general awareness of an energy problem by both the administration and occupants, and due to a combination of rising energy costs and funding cutbacks.

Upon further investigation and discussions with building maintenance personnel, reasons for the decline of energy usage become apparent. Procedures have been established to reduce thermostat settings during the heating season and to increase thermostat settings during the cooling season. Lighting levels

STATE BUILDING COMPLEX ENERGY USAGE INDEX
COMPARISON FOR 1973-1977

| Complex | Predominate Building Usage | EUI(BTU/GSF-DD) 1973 | 1977 | Percent Change In Energy Consumption |
|---|---|---|---|---|
| University of Montana | School | 24.01 | 17.19 | -28.4 |
| Western Montana College | School | 20.50 | 16.39 | -20.0 |
| Montana Tech | School | 17.36 | 14.21 | -18.1 |
| Pine Hills School for Boys | School | 31.37 | 25.73 | -18.0 |
| Home for the Aged | Apt. Complex | 32.97 | 27.13 | -17.7 |
| Capitol | Office | 15.67 | 12.99 | -17.1 |
| School for the Deaf & Blind | School | 18.56 | 15.91 | -14.3 |
| Eastern Montana College | School | 23.29 | 20.35 | -12.6 |
| Montana State University | School | 26.49 | 23.22 | -12.3 |
| Boulder River School | Hospital | 40.92 | 36.56 | -10.7 |
| Galen | Hospital | 34.55 | 31.68 | -8.3 |
| Eastmont Center | School | 21.12 | 20.29 | -3.9 |
| Mountain View School for Girls | School | 17.77 | 17.11 | -3.7 |
| Northern Montana College | School | 17.11 | 16.57 | -3.2 |
| Warm Springs State Hospital | Hospital | 39.65 | 38.46 | -3.0 |
| Veterans Home | Apt. Complex | 26.74 | 27.46 | +2.7 |
| Swan River Youth Camp[1] | Misc. | 31.97 | 37.44 | +17.1 |
| All Buildings | | 27.71 | 23.97 | -13.5% |

1 Based on estimates.

Figure 3.4

are reduced and time clocks control operation of building equipment. Weather-stripping and caulking of doors and windows and in general, a tightening of buildings against air leakage has been accomplished.

In some cases, minor retrofit projects and revision of air handling units has been accomplished. In two building complexes, the University of Montana and the Capitol complex, a relatively major capital investment in the form of a centralized load shedding and monitoring system has been installed. Eastern Montana College has installed a system, but it is not yet operational. These load shedding and monitoring systems can assist in energy conservation by starting and stopping equipment in relation to building occupancy. These same functions can be accomplished with conventional time clocks and temperature controls, but a central control system can provide quicker feedback on potential areas of equipment malfunction or temperature control system failure.

From these energy conservation efforts already accomplished, significant cost savings have also been achieved. The estimated energy costs of the 16 building complexes as a total system for 1978, adjusted for an average year, is $3,800,000.00. If no energy conservation had been accomplished, the estimated energy cost would have been $4,400,00.00 for the sixteen building complex. This is a savings of $600,000.00 to the taxpayers of Montana for 1978 over the base year of 1973.

From this audit information, the building complexes appear to fall into a series of categories. The largest energy saver, the University of Montana, appears in a category that has completed most of the low capital investment energy saving options and has invested in some large capital investments to achieve 28.4% energy savings. A following group with energy savings of 17% to 20% have accomplished most low capital energy saving options but no large capital investment

retrofit options. The next group, ranging from 8% to 14% energy reductions, have accomplished some low capital energy saving options, but can achieve larger savings by accomplishing all low cost options available. The last category, -2% to 4% energy reductions, are building complexes that have apparently done little to conserve energy, but represent a potential for additional savings.

From Figures 3.1 to 3.4 several important conclusions can be derived which provide insight for an energy conservation program. First, due to the large quantity of energy used in hospitals, the possibility of saving energy is greatest in this type of building. Second, even though electrical consumption is relatively small, the cost is high, indicating that electric consumption should not be ignored. Next, there appears to be a maximum percentage of energy savings that can be achieved through low capital investment energy saving options. This percentage appears to be close to 20%. Further savings appear to require high capital investment options such as that which has been accomplished at the University of Montana. Furthermore, saving energy results in substantial tax dollar savings.

SECTION: 4. RECOMMENDED PROGRAM

The previous section demonstrated that the State of Montana is saving sizeable amounts of tax dollars through a relatively small capital intensive energy conservation program. However, to realize savings significantly greater than that currently achieved, a substantial expenditure of capital is required to apply energy conservation on a larger basis to state-owned buildings. Nevertheless, the size of any capital expenditure for an energy conservation program is not an arbitrary figure from an economic standpoint. As additional money is invested in energy conservation, additional dollar savings will be generated through reduction in energy consumption. But, the additional dollar savings through reduced energy consumption is not proportional to the additional investment. Using results from other energy conservation programs, a general trend between the cost of a series of energy saving alternatives and the dollar savings generated by each successive alternative, has been noted. Initially a relatively large amount of energy dollars can be saved for a small investment, but as the amount of energy remaining to be saved decreases, the energy dollar savings decreases in relationship to the investment. At some point, because of this diminishing returns trend, the generated dollar savings are not economically viable, therefore an optimum level of investment must be found in order to maximize the return on investment.

Based on programs developed in the private sector and more recently in the public sector, the following program, presented in five stages is suggested for the State of Montana to achieve energy savings in state-owned buildings and maximize the return on the dollars invested: 1. An education program for occupants controlling energy uses within individual buildings; 2. Installation of building energy meters; 3. A building energy monitoring program; 4. Analysis of individual building energy use and an economical investigation of possible

retrofit, energy saving, options, and; 5. Retrofit or installation of energy saving options based on the specific building's retrofit analysis. One program stage, the educational program, can be conducted independently of all other stages; however the remaining four stages are interdependent for effective total program implementation.

An education program consists of widely distributed literature in the form of pamphlets and, secondly, seminars for building operating and maintenance personnel to familiarize them with the goals and objectives of the energy conservation program. The primary pamphlet, an Energy Conservation Guide, has already been developed and printed for distribution as part of this project.

The Energy Conservation Guide consists of sections describing energy saving options that can be affected through building operation, maintenance, and low capital retrofit investment. Specific sections detail operations of standard heating, ventilating, and cooling equipment for both human occupants and computer systems. Other energy savings options are outlined in sections describing indoor and outdoor lighting, domestic hot water operations, and weatherization of the building envelope.

Supplementary energy conservation guides would need to be prepared under the proposed program, to consist of the same general format, but to also include tailor made for Montana, economically optimum energy saving options for a building's operation and maintenance. In addition to directly resultant energy savings, an education program is expected to maintain building equipment in better condition.

The second part of the educational program stage consists of conducting seminars for building operation and maintenance personnel. From these seminars, awareness, initiative and ingenuity are expected to be instilled in the

participants. These meetings will also provide an avenue for state building designers, energy conservationists, and building operation and maintenance personnel to discuss their specific problems and solutions with building energy use.

The remaining four program stages, as stated previously, are sequentially dependent. The metering stage involves installing electric, gas, and other necessary meters to determine energy consumption of individual state-owned buildings. Buildings of a significant size (over 5,000 square feet) should be individually metered since these buildings represent the greatest opportunity for energy conservation. As part of this project, 75 buildings over 5,000 square feet have been metered. Approximately 76 buildings had been previously metered (Ref. Appendix 2 for the list of new metered buildings).

From data provided by the Montana Department of Administration, Architect and Engineering Division, approximately 110 buildings over 5,000 square feet remain to be metered. Knowledge of building energy consumption in itself will not directly save energy, but building metering is a prerequisite for building energy monitoring, program stage three.

Stage three, building energy monitoring, consists of an individual computerized building energy audit (similar in format to the building complex audit in Appendix 5) and a follow-up corrective action program. Using data as a result of program stage two, and using data reduction techniques to obtain individual building EUI'S (Ref. Section 3), a building energy audit listing can be prepared. This listing can be used to compare energy consumption between buildings and to compare year-to-year energy consumption of the same building.

For instance, buildings with low EUI's can be investigated to determine how they operate and thus extend these operating procedures to a similar class of buildings. Likewise, buildings within the same class exhibiting high EUI's may indicate maintenance problems, differing operating characteristics, etc.

With time, a history of each building's energy consumption can be mapped. For example, a building whose annual energy consumption increases, will be noted on a computerized energy audit, then the building can be investigated for reasons as to why it had an increase in energy usage. If a building has been retrofitted or energy conservation options applied then the energy audit can be used to determine if the efforts have been successful.

In addition to the above uses, the energy monitoring program can target buildings with relatively high EUI's as good candidates for building retrofit (program stage four).

Stage four of the program will survey individual buildings to determine how energy is used and dispersed in the building and then to propose capital intensive energy saving options. These options would be subjected to a life cycle analysis (Ref. Section 6) to determine the economic feasibility of each proposed option in order to maximize the rate of return on the dollar invested. This stage of the program involves predominantly all buildings with a gross floor area exceeding 5,000 square feet, approximately 260 buildings.

This report includes a life cycle analysis of twenty buildings (Ref. Section 6) leaving an estimated 240 unsurveyed buildings. Because of the small amount of data available for individually metered buildings, these 20 buildings were selected without a building energy audit, but were selected because of the availability of data. However, under the proposed program, as more data becomes

available from the building energy audits with the installation of more meters, high energy users would be targeted for analysis first since the potential for saving energy is greatest with these buildings.

As program stage four is relatively expensive on an individual building basis, it is estimated that a certain number of buildings could be subjected to an abbreviated energy survey. After completing approximately 150 detailed building surveys, a sufficiently sized sampling of each building category should exist so that the remaining buildings could receive an abbreviated analysis.

The last program stage, stage five, would use the individual building survey reports to implement the economically viable capital intensive energy saving options. These options will generally require major building changes in the form of retrofitting the building energy consuming equipment and the building envelope. This stage is the major capital cost of the proposed programs, but it also provides the greatest amount of additional energy savings of the entire program.

As with any program, costs must be evaluated against the estimated savings. The table in Figure 4.1 details the estimated costs for the first four program stages. The educational stage is comprised of two Energy Conservation Guide supplements and six semiannual seminar meetings spread over a 3-year period. The metering stage, metering of the estimated remaining 110 major buildings, involves installing half of the meters in 1979 and the rest in 1980. The monitoring program, a computerized building energy audit and a preliminary analysis of the results is shown through 1983, but is expected to be maintained in succeeding years as an ongoing monitoring program. Since an energy consumption reporting network has already been established by the State of Montana, new funding for raw data gathering is not required. The cost of program stage three is $5,000 per year in 1979 dollars.

PROGRAM COSTS[1]

| | 1979 | 1980 | 1981 | 1982 | 1983 |
|---|---|---|---|---|---|
| 1. Education | 10,000 | 5,000 | 2,000 | 0 | 0 |
| 2. Install Meters | 85,200 | 90,300 | 0 | 0 | 0 |
| 3. Monitoring Program | 5,000 | 5,300 | 5,600 | 6,000 | 6,300 ... |
| 4. Building Surveys | 175,000 | 185,500 | 196,600 | 153,000 | 0 |
| TOTALS | 275,200 | 286,100 | 204,200 | 159,600 | 6,300 |

Figure 4.1

[1]Costs are inflated annually at 6%.

The next itemized program stage is the building survey stage. The stage consists of completing approximately 50 building energy surveys annually for three years, then completing the estimated remaining 80 buildings with a condensed building survey format. All costs for the previous four program stages are based on costs that have been incurred for similar building energy conservation programs.

The final program stage, retrofitting buildings with economically sound energy saving options, requires an indepth analysis to produce a cost estimate. To obtain an estimate, data from previous building surveys completed by Drapes Engineering, in addition to the twenty survey reports included in this report (Ref. Section 7) have been reduced to derive the graph in Figure 4.2. The intent of the data reduction method is to provide a means to estimate the cost of retrofitting a group of buildings to save a certain amount of energy. The first 20% of energy savings shown on Figure 4.2 represent low investment energy saving options such as were discussed earlier in Section 3. Since the cost of low investment options can and has been achieved within the framework of existing operation and maintenance budgets only the costs for high investment energy saving options are shown on this graph. The base year, the year from which energy savings are calculated, is 1973. As shown on the graph, as of 1977, 13.5% has been saved. Based on discussions earlier in Section 3, 20% is the estimated maximum energy savings possible from low investment energy saving options. Savings of greater than 20% will require major capital investment options. The capital investment required for a group of buildings is estimated by the curved portion of the graph. For instance, to realize a total average savings of 40% when compared to the base year for a large group of buildings, an average investment of $.79 per gross square foot of floor area is needed. A

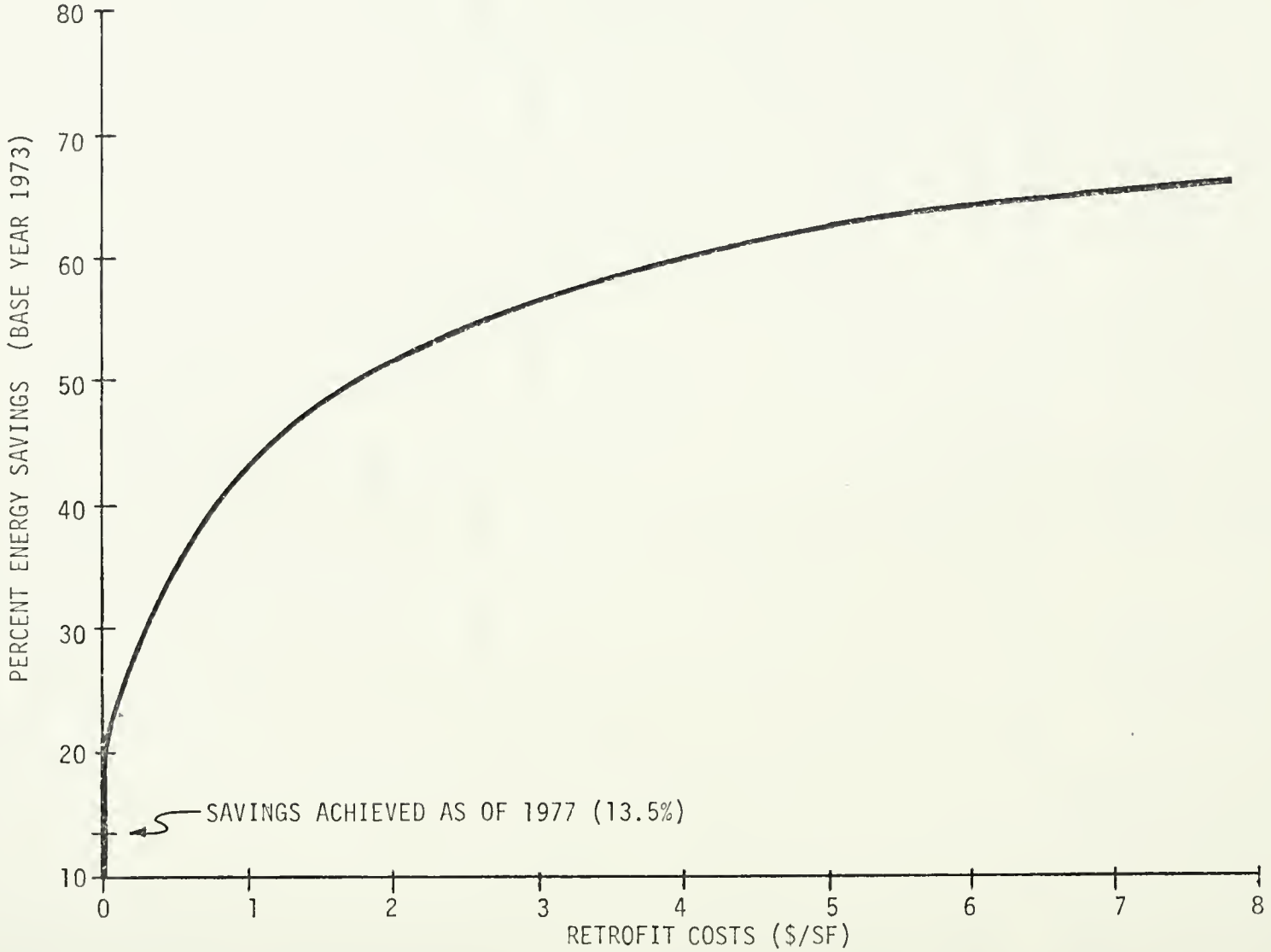



FIGURE 4.2 PROGRAM ENERGY SAVINGS VERSUS RETROFIT COSTS

word of caution on the use of Figure 4.2: since the data is derived from a large group of buildings and is reduced to a few graphical points, the graph applies to only a group of buildings and extracted graphical information represents only an average for the entire building group. Consequently costs and savings for individual buildings may deviate from the curve. One conclusion that can be drawn from this graph is that energy conservation in buildings follows a curve of diminishing returns. For each additional dollar invested, less and less energy is saved.

Now that a method to determine the cost of major investment energy conservation options has been developed, a procedure is next needed to determine an energy conservation goal. The fixing of a goal will then determine the required retrofit investment. This goal should be based on maximizing the rate of return on investment. A life cycle analysis using the time value of money concept (Ref. Section 6) will determine optimum levels of investment to achieve a maximum rate of return.

Economic parameters for this life cycle economic analysis includes a rate of return of 7%, a general inflation rate of 6%, projected average 1979 energy costs, and an energy inflation rate 4% higher than the general inflation rate. Calculated energy costs consider both the cost of electricity and heating fuels. The program life is extended through the year 2000. Since the life cycle economic analysis accounts for the time value of money, the retrofit investments are expended over different time periods: a 20-year time period; a 10-year time period; and a 5-year time period. Overall program costs and savings for each of these three scenarios is presented in Figure 4.3. In each case two million dollars is expended in the 1979-1980 biennium for retrofit options, and the remaining required expenditure is distributed evenly over the remaining specific time period.

Since the estimated retrofit cost is dependent on the amount of floor area to be retrofitted, a figure for the amount of area to be retrofitted must be selected. Data furnished by the Department of Natural Resources, Energy Planning Division, indicate there is approximately 15 million gross square feet of building floor area presently owned by the State of Montana. However, a portion of this figure includes buildings that are unheated such as vehicle storage garages and animal barns, or buildings used only for summer occupancy, buildings with minimal heating requirements such as maintenance garages and warehouses, and buildings that the utility bills are paid for by the occupants such as faculty and married student housing. Of the total floor area owned by the State of Montana, approximately 10 million square feet are buildings that are suitable for retrofit.

Using the graph in Figure 4.2 and approximately 10 million square feet of retrofit building area, the total retrofit costs can be derived. Consequently, the total cost to achieve an energy conserving level can be determined by combining the retrofit costs with the costs in Figure 4.1 for the other program costs. By varying the retrofit costs to achieve different program savings, the graph in Figure 4.3 can be developed. This graph plots the net present worth of program savings as a function of total program cost and the corresponding percent energy savings. Due to the time value of money, the three above described expenditure periods result in a family of curves.

The obvious and expected conclusion noted from Figure 4.3 is that there is an optimum energy conserving percentage value. Next, as the family of curves demonstrate, the sooner a retrofit program is accomplished, the greater the monetary savings to the State of Montana. There is a compounding factor in this

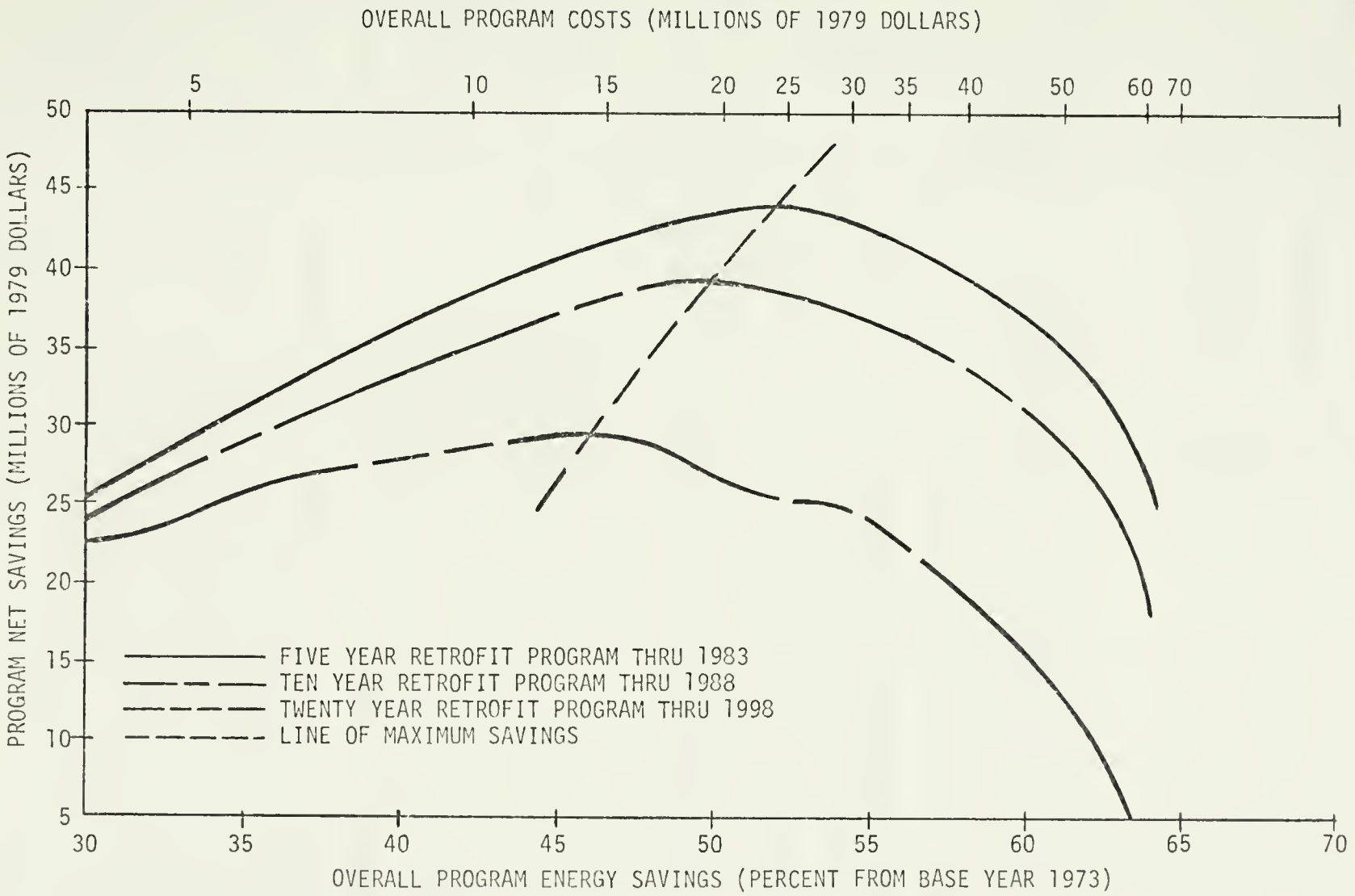



FIGURE 4.3 PROGRAM NET SAVINGS VERSUS ENERGY SAVINGS

last conclusion: not only does the State realize greater savings at a sooner time, ergo, increasing the savings of the program, but also a shift to a greater optimum energy conserving point occurs, ergo further fuel cost savings. The shifting of the optimum energy saving point is graphed by the dashed line in Figure 4.3.

Using the respective optimum energy conserving points, the tables shown in Figures 4.4, 4.5, and 4.6 are constructed to show a year-by-year breakdown of the three program scenarios' costs and savings. Total savings of the three proposed programs range from 29 million to 43 million dollars for initial investments ranging from 13 million to 21 million dollars.

The previously described program addresses the best method to lower energy consumption and save tax dollars for state-owned buildings in Montana. However, there is one aspect of building energy consumption that has not been investigated, the amount of energy required to produce and transmit the consumed energy to the building. For instance, suppose a building uses natural gas and electricity for energy sources. To transport the natural gas to the boiler burner requires some amount of pumping energy from the natural gas well head to the building. In the case of electricity produced with heat processes, an energy conversion from a basic energy source to electricity is required through a thermodynamic process which is 30% to 40% efficient. In addition, some amount of energy is required for transmission of the electricity to the user. Consequently, an energy utilization index can be developed to account for these energy losses due to conversion and transportation efficiencies. This index, the resource utilization factor (RUF), has been developed and compiled by the Federal Government's Department of Energy (DOE). The national average RUF's are:

LIFE CYCLE ANALYSIS TABLE WITH A RETROFIT PROGRAM
EXTENDING THRU 1983 (1000'S $'S)

| YEAR | DEVELOPMENT, EDUCATION, & FOLLOW-UP PROGRAM COSTS | SURVEY COSTS | METERING COSTS | RETROFIT COSTS | ENERGY COSTS W/O PROGRAM | SAVINGS RESULTING FROM FURTHER EDUCATION | SAVINGS RESULTING FROM RETROFIT | ENERGY COSTS W/PROGRAM | TOTAL ENERGY SAVINGS | PROGRAM CASH FLOW |
|---|---|---|---|---|---|---|---|---|---|---|
| 1977 | 0 | 0 | 0 | 0 | 3,803 | 0 | 0 | 3,803 | 0 | 0 |
| 1978 | 30 | 75 | 95 | 0 | 4,226 | 49 | 0 | 4,177 | 49 | -151 |
| 1979 | 15 | 175 | 85 | 1,000 | 5,052 | 176 | 0 | 4,876 | 176 | -1,099 |
| 1980 | 10.3 | 186 | 90 | 1,000 | 5,558 | 412 | 105 | 5,041 | 517 | -769 |
| 1981 | 7.6 | 197 | 0 | 7,282 | 6,113 | 466 | 232 | 5,415 | 698 | -6,789 |
| 1982 | 6.0 | 154 | 0 | 7,719 | 6,725 | 512 | 1,082 | 5,131 | 1,594 | -6,285 |
| 1983 | 6.3 | 0 | 0 | 8,182 | 7,397 | 604 | 2,092 | 4,701 | 2,696 | -5,492 |
| 1984 | 6.7 | 0 | 0 | 0 | 8,137 | 664 | 3,302 | 4,171 | 3,966 | 3,959 |
| 1985 | 7.1 | 0 | 0 | 0 | 8,951 | 730 | 3,632 | 4,589 | 4,362 | 4,355 |
| 1986 | 7.5 | 0 | 0 | 0 | 9,846 | 804 | 3,995 | 5,047 | 4,799 | 4,792 |
| 1987 | 8.0 | 0 | 0 | 0 | 10,830 | 884 | 4,394 | 5,552 | 5,278 | 5,270 |
| 1988 | 8.4 | 0 | 0 | 0 | 11,910 | 972 | 4,834 | 6,104 | 5,806 | 5,798 |
| 1989 | 9.0 | 0 | 0 | 0 | 13,100 | 1,070 | 5,317 | 6,713 | 6,387 | 6,378 |
| 1990 | 9.5 | 0 | 0 | 0 | 14,420 | 1,176 | 5,849 | 7,395 | 7,025 | 7,016 |
| 1991 | 10.1 | 0 | 0 | 0 | 15,860 | 1,294 | 6,434 | 8,132 | 7,728 | 7,718 |
| 1992 | 10.7 | 0 | 0 | 0 | 17,440 | 1,424 | 7,077 | 8,939 | 8,501 | 8,490 |
| 1993 | 11.3 | 0 | 0 | 0 | 19,190 | 1,566 | 7,785 | 9,839 | 9,351 | 9,340 |
| 1994 | 12.0 | 0 | 0 | 0 | 21,110 | 1,722 | 8,563 | 10,830 | 10,290 | 10,280 |
| 1995 | 12.7 | 0 | 0 | 0 | 23,220 | 1,895 | 9,420 | 11,910 | 11,320 | 11,310 |
| 1996 | 13.5 | 0 | 0 | 0 | 25,540 | 2,084 | 10,360 | 13,100 | 12,440 | 12,430 |
| 1997 | 14.3 | 0 | 0 | 0 | 28,090 | 2,293 | 11,400 | 14,400 | 13,690 | 13,680 |
| 1998 | 15.1 | 0 | 0 | 0 | 30,900 | 2,522 | 12,540 | 15,840 | 15,060 | 15,040 |
| 1999 | 16.0 | 0 | 0 | 0 | 33,990 | 2,774 | 13,790 | 17,430 | 16,540 | 16,550 |
| 2000 | 17.0 | 0 | 0 | 0 | 37,390 | 3,052 | 15,170 | 19,170 | 18,220 | 18,200 |

PRESENT WORTH OF PROGRAM CASH FLOW (NET SAVINGS) = $43,160,000 (1979 $'S)
TOTAL PROGRAM ENERGY SAVINGS WITH RESPECT TO 1973 CONSUMPTION = 52%
TOTAL RETROFIT BUDGET = $21,387,000 (1979 $'S)
TOTAL BUILDING AREA AFFECTED BY RETROFIT PROGRAM = 10,280,000 SQUARE FEET
GENERAL INFLATION RATE = 6%
ENERGY INFLATION RATE = 10%
RATE OF RETURN = 7%

FIGURE 4.4

LIFE CYCLE ANALYSIS TABLE WITH A RETROFIT PROGRAM
EXTENDING THRU 1988 (1000'S $'S)

| YEAR | DEVELOPMENT, EDUCATION, & FOLLOW-UP PROGRAM COSTS | SURVEY COSTS | METERING COSTS | RETROFIT COSTS | ENERGY COSTS W/O PROGRAM | SAVINGS RESULTING FROM FURTHER EDUCATION | SAVINGS RESULTING FROM RETROFIT | ENERGY COSTS W/PROGRAM | TOTAL ENERGY SAVINGS | PROGRAM CASH FLOW |
|---|---|---|---|---|---|---|---|---|---|---|
| 1977 | 0 | 0 | 0 | 0 | 3,803 | 0 | 0 | 3,803 | 0 | 0 |
| 1978 | 30 | 75 | 95 | 0 | 4,226 | 49 | 0 | 4,177 | 49 | -151 |
| 1979 | 15 | 175 | 85 | 1,000 | 5,052 | 176 | 0 | 4,876 | 176 | -1,099 |
| 1980 | 10 | 186 | 90 | 1,000 | 5,558 | 412 | 116 | 5,030 | 528 | -758 |
| 1981 | 7.6 | 197 | 0 | 2,283 | 6,113 | 466 | 256 | 5,391 | 722 | -1,766 |
| 1982 | 6.0 | 154 | 0 | 2,420 | 6,725 | 512 | 567 | 5,646 | 1,079 | -1,501 |
| 1983 | 6.3 | 0 | 0 | 2,565 | 7,397 | 604 | 929 | 5,864 | 1,533 | -1,038 |
| 1984 | 6.7 | 0 | 0 | 2,719 | 8,137 | 664 | 1,367 | 6,106 | 2,031 | -695 |
| 1985 | 7.1 | 0 | 0 | 2,882 | 8,951 | 730 | 1,884 | 6,337 | 2,614 | -275 |
| 1986 | 7.5 | 0 | 0 | 3,055 | 9,846 | 804 | 2,491 | 6,551 | 3,295 | 232 |
| 1987 | 8.0 | 0 | 0 | 3,239 | 10,830 | 884 | 3,200 | 6,746 | 4,084 | 837 |
| 1988 | 8.4 | 0 | 0 | 3,433 | 11,910 | 972 | 4,026 | 6,912 | 4,998 | 1,557 |
| 1989 | 9.0 | 0 | 0 | 0 | 13,100 | 1,070 | 4,985 | 7,045 | 6,055 | 6,046 |
| 1990 | 9.5 | 0 | 0 | 0 | 14,420 | 1,176 | 5,483 | 7,761 | 6,659 | 6,650 |
| 1991 | 10.1 | 0 | 0 | 0 | 15,860 | 1,294 | 6,032 | 8,534 | 7,326 | 7,316 |
| 1992 | 10.7 | 0 | 0 | 0 | 17,440 | 1,424 | 6,635 | 9,381 | 8,059 | 8,048 |
| 1993 | 11.3 | 0 | 0 | 0 | 19,190 | 1,566 | 7,298 | 10,330 | 8,864 | 8,853 |
| 1994 | 12.0 | 0 | 0 | 0 | 21,110 | 1,722 | 8,028 | 11,360 | 9,750 | 9,738 |
| 1995 | 12.7 | 0 | 0 | 0 | 23,220 | 1,895 | 8,831 | 12,490 | 10,730 | 10,720 |
| 1996 | 13.5 | 0 | 0 | 0 | 25,540 | 2,084 | 9,714 | 13,740 | 11,800 | 11,790 |
| 1997 | 14.3 | 0 | 0 | 0 | 28,090 | 2,293 | 10,680 | 15,120 | 12,970 | 12,960 |
| 1998 | 15.1 | 0 | 0 | 0 | 30,900 | 2,522 | 11,750 | 16,630 | 14,270 | 14,250 |
| 1999 | 16.0 | 0 | 0 | 0 | 33,990 | 2,774 | 12,930 | 18,290 | 15,700 | 15,680 |
| 2000 | 17.0 | 0 | 0 | 0 | 37,390 | 3,052 | 14,220 | 20,120 | 17,270 | 17,250 |

PRESENT WORTH OF PROGRAM CASH FLOW (NET SAVINGS) = $38,360,000 (1979 $'S)
TOTAL PROGRAM ENERGY SAVINGS WITH RESPECT TO 1973 CONSUMPTION = 50%
TOTAL RETROFIT BUDGET = $18,200,000 (1979 $'S)
TOTAL BUILDING AREA AFFECTED BY RETROFIT PROGRAM = 10,280,000 SQUARE FEET
GENERAL INFLATION RATE = 6%
ENERGY INFLATION RATE = 10%
RATE OF RETURN = 7%

FIGURE 4.5

LIFE CYCLE ANALYSIS TABLE WITH A RETROFIT PROGRAM
EXTENDING THRU 1998 (1000'S $'S)

| YEAR | DEVELOPMENT, EDUCATION, & FOLLOW-UP PROGRAM COSTS | SURVEY COSTS | METERING COSTS | RETROFIT COSTS | ENERGY COSTS W/O PROGRAM | SAVINGS RESULTING FROM FURTHER EDUCATION | SAVINGS RESULTING FROM RETROFIT | ENERGY COSTS W/PROGRAM | TOTAL ENERGY SAVINGS | PROGRAM CASH FLOW |
|---|---|---|---|---|---|---|---|---|---|---|
| 1977 | 0 | 0 | 0 | 0 | 3,803 | 0 | 0 | 3,803 | 0 | 0 |
| 1978 | 30 | 75 | 95 | 0 | 4,226 | 49 | 0 | 4,177 | 49 | -151 |
| 1979 | 15 | 175 | 85 | 1,000 | 5,052 | 176 | 0 | 4,876 | 176 | -1,099 |
| 1980 | 10 | 186 | 90 | 1,000 | 5,558 | 412 | 141 | 5,005 | 553 | -733 |
| 1981 | 7.6 | 197 | 0 | 687 | 6,113 | 466 | 311 | 5,336 | 777 | -115 |
| 1982 | 6.0 | 154 | 0 | 729 | 6,725 | 512 | 447 | 5,766 | 959 | 70 |
| 1983 | 6.3 | 0 | 0 | 772 | 7,397 | 604 | 596 | 6,197 | 1,200 | 422 |
| 1984 | 6.7 | 0 | 0 | 819 | 8,137 | 664 | 782 | 6,691 | 1,446 | 620 |
| 1985 | 7.1 | 0 | 0 | 868 | 8,951 | 730 | 1,000 | 7,221 | 1,730 | 855 |
| 1986 | 7.5 | 0 | 0 | 920 | 9,846 | 804 | 1,253 | 7,789 | 2,057 | 1,130 |
| 1987 | 8.0 | 0 | 0 | 975 | 10,830 | 884 | 1,547 | 8,399 | 2,431 | 1,448 |
| 1988 | 8.4 | 0 | 0 | 1,034 | 11,910 | 972 | 1,887 | 9,051 | 2,859 | 1,817 |
| 1989 | 9.0 | 0 | 0 | 1,096 | 13,100 | 1,070 | 2,280 | 9,750 | 3,350 | 2,245 |
| 1990 | 9.5 | 0 | 0 | 1,161 | 14,420 | 1,176 | 2,732 | 10,510 | 3,908 | 2,738 |
| 1991 | 10.1 | 0 | 0 | 1,231 | 15,860 | 1,294 | 3,253 | 11,310 | 4,547 | 3,306 |
| 1992 | 10.7 | 0 | 0 | 1,305 | 17,440 | 1,424 | 3,849 | 12,170 | 5,273 | 3,957 |
| 1993 | 11.3 | 0 | 0 | 1,383 | 19,190 | 1,566 | 4,533 | 13,090 | 6,099 | 4,705 |
| 1994 | 12.0 | 0 | 0 | 1,466 | 21,110 | 1,722 | 5,315 | 14,070 | 7,037 | 5,559 |
| 1995 | 12.7 | 0 | 0 | 1,554 | 23,220 | 1,895 | 6,208 | 15,120 | 8,103 | 6,536 |
| 1996 | 13.5 | 0 | 0 | 1,647 | 25,540 | 2,084 | 7,226 | 16,230 | 9,310 | 7,650 |
| 1997 | 14.3 | 0 | 0 | 1,746 | 28,090 | 2,293 | 8,386 | 17,410 | 10,680 | 8,919 |
| 1998 | 15.1 | 0 | 0 | 1,851 | 30,900 | 2,522 | 9,706 | 18,670 | 12,230 | 10,360 |
| 1999 | 16.0 | 0 | 0 | 0 | 33,900 | 2,774 | 11,200 | 20,020 | 13,970 | 13,950 |
| 2000 | 17.0 | 0 | 0 | 0 | 37,390 | 3,052 | 12,330 | 22,010 | 15,380 | 15,360 |

PRESENT WORTH OF PROGRAM CASH FLOW (NET SAVINGS) = $28,680,000 (1979 $'S)
TOTAL PROGRAM ENERGY SAVINGS WITH RESPECT TO 1973 CONSUMPTION = 46%
TOTAL RETROFIT BUDGET = $12,960,000 (1979 $'S)
TOTAL BUILDING AREA AFFECTED BY RETROFIT PROGRAM = 10,280,000 SQUARE FEET
GENERAL INFLATION RATE = 6%
ENERGY INFLATION RATE = 10%
RATE OF RETURN = 7%

FIGURE 4.6

Natural Gas - 1.11
Oil - 1.16
Electricity - 3.04

An application of a RUF for electricity would indicate that more than 2 KWH of an equivalent basic energy source are expended to deliver 1 KWH of useable energy to the building.

Since many state-owned buildings are heated with steam supplied by a central power plant, a RUF should be calculated for steam. Using data from Montana State University, Bozeman, an average RUF for steam is equal to 1.93. This is significantly higher than the RUF for either oil or natural gas.

The major factor for exhibiting such a high RUF at MSU is due to heat losses incurred when transporting the steam through underground piping to the individual buildings. Even a change in the type of fuel, i.e. to coal, will still result in relative high RUF's for central heat distribution systems as when compared with individual building heating plants because the distribution losses are still incurred. Consequently, a separate investigation should be undertaken to study possible alternatives to effect greater efficiencies in delivering energy to individual buildings. However, due to the intent of addressing conservation in individual buildings with this project, an investigation of central distribution heating plans is not included, but should be evaluated in a separate study by the State of Montana.

In summary, the recommended energy conservation program for state-owned buildings requires investments for an educational program, a building metering program, an individual building survey program and a building retrofit program. The apparent initial investment costs for a commitment to energy conservation for state-owned buildings appears high. However, the life cycle costs for an energy conservation program are actually lower than spending no money for energy

conservation. A commitment to energy conservation to save energy represents one of the few opportunities to save tax dollars by spending tax dollars and will ultimately save millions of dollars for the taxpayers of Montana.

SECTION: 5. BUILDING ENERGY AUDIT

As part of this study, a building energy audit was conducted on the available metered state-owned buildings. Pages 5.3 thru 5.27 are the results of the available 97 metered buildings audit.

Pages 5.3 through 5.7 show the buildings listed in an alphabetic listing; next, Pages 5.8 through 5.11 order the buildings by the weighted percent of each building's energy consumed as compared against the total group's consumption; pages 5.12 through 5.15 orders the buildings based on their respective EUI (BTU/GSF-DD) in decreasing sequence; and last, a series of listings based on a breakdown of building usage categories based on each building's EUI (BTU/GSF/DD) in decreasing sequence. Except for a few isolated cases, the data is used as it was received.

From this listing, buildings can be targeted for the building survey stage of the proposed program. For instance, the Kalispell Special Forces Armory (KALIS-S.F.) is listed as a relatively high energy user as shown in the Armory category listing. A review of the data used to calculate the EUI reveals no major inconsistencies in the Kalispell Special Forces Armory data, consequently, a more detailed investigation is required to determine the reason for the high EUI.

Another important factor to consider when determining which buildings are to be surveyed for energy saving options is to give the highest priority for a detailed investigation to those buildings with both a high EUI and a high total energy consumption. For instance, the Veteran's Home at Columbia Falls is not only a relatively inefficient energy user, but also consumes 4.5% of its building group's total energy. Therefore, not only is the potential for saving energy great for the Veteran's Home, the potential quantity of energy saved is also very great when compared to the other buildings in the audit.

As a history of data on each building is developed, another analysis technique, comparisons on a yearly basis, can be developed. The listing in Figure 5.1 is a sample of a yearly comparison that was done for the Mountain Bell Company, Montana Division. This listing can point out buildings that have experienced either increases or decreases in energy consumption. Consequently, this is another means to detect errant building energy consumption or follow-up on buildings that have been retrofitted.

# DESCRIPTION OF OUTPUT LISTING

LOCATION: CITY NAME, (MONTANA ASSUMED AS THE STATE, UNLESS SPECIFIED OTHERWISE).

BUILDING TYPE: DESCRIBES MAJOR USE OF FACILITY.

BUILDING AREA: TOTAL AREA OF ALL FLOORS, IN GROSS SQUARE FEET (GSF).

HEATING DEGREE DAYS: ANNUAL TOTAL OF DIFFERENCE BETWEEN DAILY MEAN TEMP. AND 65 °F.

ENERGY CONSUMPTION: BASED ON UTILITY BILLING RECORDS.

GAS: AMOUNT USED DURING THE YEAR, IN THOUSANDS OF CUBIC FEET, (MCF).

ELECTRIC: AMOUNT USED DURING THE YEAR, INDICATED IN THOUSANDS OF KWH, (MKWH).

OTHER: ANY OTHER ENERGY SOURCE,LISTED BY ENERGY CONTENT IN MILLIONS OF BTU, (MMBTU).

TOTAL: AMOUNT OF ENERGY USED DURING AUDIT YEAR, IN MILLIONS OF BTU, (MMBTU).

USAGE OF ENERGY:

BTU/GSF-YR IS A PARAMETER PROVIDING A COMMON BASIS OF COMPARISON OF ENERGY USAGE FOR BUILDINGS HAVING SIMILAR CLIMATIC CONDITIONS. 'AVERAGE' VALUES OF THIS PARAMETER ARE COMPUTED AS THE RATIO OF THE TOTAL ENERGY USED TO THE TOTAL GROSS FLOOR AREA.

BTU/GSF-DEG.DAY IS A PARAMETER PROVIDING A COMMON BASIS OF COMPARISON OF BUILDING ENERGY USAGE REGARDLESS OF CLIMATE OR YEAR. 'AVERAGE' VALUES OF THIS PARAMETER ARE WEIGHTED AVERAGES, WEIGHTED BY THE % OF TOTAL ENERGY USE.

ALPHABETIC LISTING

| NO. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | USAGE OF ENERGY BTU/GSF /YR | BTU/GSF /DD | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ABER | U. OF M. | DORMITORY | 87951 | 7689 | 0 | 505 | 6836 | 8558 | 97303 | 12.65 | 1.811 |
| 2 | ANACONDA | ANACONDA | ARMORY | 10000 | 8164 | 1576 | 23 | 0 | 1498 | 149767 | 18.34 | .317 |
| 3 | ANML SHLTR | HELENA | MISC | 408 | 7766 | 0 | 1 | 0 | 5 | 12397 | 1.60 | .001 |
| 4 | APSARUKE | E.M.C. | INDSTRL | 20119 | 6352 | 2212 | 104 | 0 | 2347 | 116647 | 18.36 | .497 |
| 5 | AVTN MAINT | HELENA | INDSTRL | 17204 | 7766 | 4255 | 290 | 0 | 4820 | 280183 | 36.08 | 1.020 |
| 6 | BILLINGS | BILLINGS | ARMORY | 16260 | 6352 | 2277 | 51 | 0 | 2224 | 136757 | 21.53 | .471 |
| 7 | BOZEMAN | BOZEMAN | ARMORY | 28000 | 7537 | 2270 | 30 | 0 | 2147 | 76674 | 10.17 | .454 |
| 8 | BUTTE | BUTTE | ARMORY | 9155 | 9142 | 1526 | 29 | 0 | 1472 | 160818 | 17.59 | .312 |
| 9 | CHINOOK | CHINOOK | ARMORY | 9132 | 7983 | 1056 | 16 | 0 | 1006 | 110158 | 13.80 | .213 |
| 10 | CNTR F AGD | LEWISTOWN | APT CMPLX | 74764 | 8651 | 17651 | 487 | 0 | 17549 | 234721 | 27.13 | 3.714 |
| 11 | CNTRL WHSE | MISSOULA | GARAGE | 5112 | 7689 | 390 | 47 | 0 | 510 | 99848 | 12.99 | .108 |
| 12 | CNYN FRRY | HELENA | MISC | 650 | 7766 | 0 | 3 | 126 | 137 | 210034 | 27.05 | .029 |
| 13 | COBLEIGH | M.S.U. | OFFICE | 92741 | 7537 | 0 | 845 | 15816 | 18701 | 201645 | 26.75 | 3.958 |
| 14 | CRASH RESC | WYELLOWSTN | GARAGE | 3674 | 10641 | 0 | 8 | 20 | 48 | 13106 | 1.23 | .010 |
| 15 | CRBN-BRTLY | U. OF M. | DORMITORY | 73699 | 7689 | 0 | 222 | 7201 | 7960 | 108010 | 14.05 | 1.685 |
| 16 | CRG & DNWY | U. OF M. | DORMITORY | 110843 | 7689 | 0 | 402 | 7190 | 8563 | 77249 | 10.05 | 1.812 |
| 17 | CRTV. ARTS | M.S.U. | CLASSROOM | 135012 | 7537 | 0 | 1690 | 6462 | 12230 | 90588 | 12.02 | 2.588 |
| 18 | DEER LODGE | DEER LODGE | ARMORY | 7600 | 8617 | 0 | 33 | 1006 | 1119 | 147174 | 17.08 | .237 |
| 19 | DILLON | DILLON | ARMORY | 7780 | 7730 | 1239 | 12 | 0 | 1157 | 148723 | 19.24 | .245 |
| 20 | DISP WHSE | MISSOULA | GARAGE | 4964 | 7689 | 581 | 28 | 0 | 619 | 124639 | 16.21 | .131 |
| 21 | E.S.C. | CAP CMPLX | OFFICE | 49621 | 7766 | 4525 | 580 | 0 | 6054 | 121998 | 15.71 | 1.281 |
| 22 | ELROD | U. OF M. | DORMITORY | 34323 | 7689 | 0 | 118 | 3347 | 3751 | 109288 | 14.21 | .794 |
| 23 | F&G #2HQ | MISSOULA | OFFICE | 1832 | 7537 | 503 | 17 | 0 | 512 | 279474 | 37.08 | .108 |
| 24 | F&G #6HQ | GLASGOW | OFFICE | 1924 | 8754 | 185 | 10 | 0 | 200 | 104013 | 11.88 | .042 |
| 25 | F&G DRAFT | HELENA | OFFICE | 2136 | 7766 | 199 | 7 | 0 | 204 | 95407 | 12.29 | .043 |
| 26 | F&G HANGER | HELENA | GARAGE | 5600 | 7766 | 985 | 4 | 0 | 902 | 161029 | 20.74 | .191 |
| 27 | F&G HQ | HELENA | OFFICE | 31040 | 7766 | 1900 | 222 | 0 | 2467 | 79462 | 10.23 | .522 |
| 28 | F&G I&E | HELENA | OFFICE | 2304 | 7766 | 395 | 7 | 0 | 379 | 164310 | 21.16 | .080 |
| 29 | F&G WHSE | HELENA | GARAGE | 6000 | 7766 | 0 | 3 | 0 | 9 | 1514 | .19 | .002 |
| 30 | F&G WHSE | HELENA | GARAGE | 4800 | 7766 | 579 | 17 | 0 | 578 | 120468 | 15.51 | .122 |
| 31 | FIELD HS. | M.S.U. | SPRT CMPL | 104600 | 7537 | 0 | 649 | 11301 | 13516 | 129213 | 17.14 | 2.860 |
| 32 | FIELD HS. | U. OF M. | SPRT CMPL | 169449 | 7689 | 0 | 384 | 7784 | 9094 | 53665 | 6.98 | 1.924 |

ALPHABETIC LISTING

| NO. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | USAGE OF ENERGY BTU/GSF /YR | BTU/GSF /DD | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 33 | FIRE EQUP. | MISSOULA | GARAGE | 3916 | 7689 | 412 | 10 | 0 | 403 | 103001 | 13.40 | .085 |
| 34 | FIRE PREV | MISSOULA | GARAGE | 2700 | 7689 | 72 | 3 | 0 | 75 | 27862 | 3.62 | .016 |
| 35 | FRSTRY HQ. | MSLA - DNRC | OFFICE | 4954 | 7689 | 317 | 53 | 0 | 465 | 93902 | 12.21 | .098 |
| 36 | GARRETT | HELENA | OFFICE | 2839 | 7766 | 286 | 8 | 0 | 285 | 100372 | 12.92 | .060 |
| 37 | GLASGOW | GLASGOW | ARMORY | 9400 | 8754 | 974 | 23 | 0 | 954 | 101485 | 11.59 | .202 |
| 38 | GLENDIVE | GLENDIVE | ARMORY | 8814 | 7324 | 1199 | 35 | 0 | 1197 | 135780 | 18.54 | .253 |
| 39 | GRAIN LAB | GREAT FALLS | OFFICE | 5325 | 7511 | 671 | 55 | 0 | 790 | 148391 | 19.76 | .167 |
| 40 | GREENHOUSE | M.S.U. | MISC | 16878 | 7537 | 0 | 232 | 2208 | 3000 | 177725 | 23.58 | .635 |
| 41 | HAMILTON | HAMILTON | ARMORY | 9597 | 7288 | 742 | 19 | 0 | 733 | 76359 | 10.48 | .155 |
| 42 | HANNON | M.S.U. | DORMITORY | 91011 | 7537 | 0 | 414 | 6767 | 8181 | 89891 | 11.93 | 1.731 |
| 43 | HAPNER | M.S.U. | DORMITORY | 94612 | 7537 | 0 | 535 | 7111 | 8937 | 94456 | 12.53 | 1.891 |
| 44 | HARLOWTON | HARLOWTON | ARMORY | 3200 | 7500 | 787 | 11 | 0 | 744 | 232611 | 31.01 | .158 |
| 45 | HDGS CMPLX | M.S.U. | DORMITORY | 401569 | 7537 | 0 | 3801 | 37573 | 50544 | 125867 | 16.70 | 10.697 |
| 46 | HEALTH SRV | U. OF M. | HOSPITAL | 34658 | 7689 | 0 | 332 | 3702 | 4837 | 139553 | 18.15 | 1.024 |
| 47 | HI. HANGER | HELENA | GARAGE | 7070 | 7766 | 1103 | 24 | 0 | 1076 | 152167 | 19.59 | .228 |
| 48 | HI. PATROL | BUTTE | OFFICE | 2176 | 9142 | 387 | 27 | 0 | 442 | 202960 | 22.20 | .093 |
| 49 | HLN ARM. | HELENA | ARMORY | 48854 | 7766 | 4778 | 170 | 0 | 4879 | 99877 | 12.86 | 1.033 |
| 50 | JESSE | U. OF M. | DORMITORY | 87951 | 7689 | 0 | 475 | 6835 | 8455 | 96138 | 12.50 | 1.789 |
| 51 | KALIS-S.F. | KALISPELL | ARMORY | 3200 | 8149 | 1181 | 31 | 0 | 1167 | 364585 | 44.74 | .247 |
| 52 | KALISPELL | KALISPELL | ARMORY | 14664 | 8149 | 2489 | 58 | 0 | 2437 | 166214 | 20.40 | .516 |
| 53 | KNOWLES | U. OF M. | DORMITORY | 67078 | 7689 | 0 | 235 | 5284 | 6085 | 90715 | 11.80 | 1.288 |
| 54 | L. JOHNSON | M.S.U. | CLASSROOM | 112011 | 7537 | 0 | 545 | 13570 | 15432 | 137769 | 18.28 | 3.266 |
| 55 | LANGFORD | M.S.U. | DORMITORY | 106399 | 7537 | 0 | 502 | 7607 | 9322 | 87615 | 11.62 | 1.973 |
| 56 | LEWISTOWN | LEWISTOWN | ARMORY | 9530 | 8651 | 1233 | 17 | 0 | 1169 | 122634 | 14.18 | .247 |
| 57 | LIBRARY | M.S.U. | CLASSROOM | 152085 | 7537 | 0 | 2138 | 6144 | 13439 | 88367 | 11.72 | 2.844 |
| 58 | LIBRARY | U. OF M. | CLASSROOM | 216558 | 7689 | 0 | 1802 | 8447 | 14598 | 67407 | 8.77 | 3.089 |
| 59 | LODGE | U. OF M. | MPLX CNTR | 85041 | 7689 | 0 | 872 | 5657 | 8633 | 101521 | 13.20 | 1.827 |
| 60 | LVSTCK PVL | M.S.U. | MISC | 23607 | 7537 | 3809 | 85 | 0 | 3717 | 157466 | 20.89 | .787 |
| 61 | M.A.C. OPR | HELENA | INDSTRL | 8557 | 7766 | 614 | 24 | 0 | 636 | 74299 | 9.57 | .135 |
| 62 | MALTA | MALTA | ARMORY | 9400 | 8472 | 1520 | 20 | 0 | 1438 | 152926 | 18.05 | .304 |
| 63 | MC GREGOR | HELENA | OFFICE | 2197 | 7766 | 194 | 8 | 0 | 201 | 91411 | 11.77 | .043 |
| 64 | MILES CITY | MILES CITY | ARMORY | 7738 | 7357 | 915 | 25 | 0 | 911 | 117668 | 15.99 | .193 |

ALPHABETIC LISTING

| NO. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION | | | | USAGE OF ENERGY | | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | BTU/GSF /YR | BTU/GSF /DD | |
| 65 | MILLER | U. OF M. | DORMITORY | 64628 | 7689 | 0 | 328 | 6168 | 7286 | 112737 | 14.66 | 1.542 |
| 66 | MNTL HLTH | BILLINGS | OFFICE | 20000 | 6352 | 1373 | 143 | 0 | 1723 | 86151 | 13.56 | .365 |
| 67 | MORGAN | N.M.C. | DORMITORY | 50938 | 7983 | 9357 | 178 | 0 | 9029 | 177264 | 22.21 | 1.911 |
| 68 | MRRD STDNT | N.M.C. | APT CMPLX | 37029 | 7983 | 5742 | 181 | 0 | 5784 | 156205 | 19.57 | 1.224 |
| 69 | NRSRY OFF | MISSOULA | OFFICE | 2800 | 7689 | 132 | 23 | 0 | 199 | 70932 | 9.23 | .042 |
| 70 | ORG. MAINT | BELGRADE | INDSTRL | 1944 | 8367 | 519 | 10 | 0 | 500 | 257368 | 30.76 | .106 |
| 71 | ORG. MAINT | CULBERTSON | INDSTRL | 2664 | 8700 | 0 | 12 | 287 | 329 | 123682 | 14.22 | .070 |
| 72 | P.E.R.S. | CAP. CMPLX | OFFICE | 7200 | 7766 | 248 | 36 | 0 | 345 | 47879 | 6.17 | .073 |
| 73 | PET. STAT. | BILLINGS | OFFICE | 5360 | 6352 | 441 | 22 | 0 | 470 | 87731 | 13.81 | .100 |
| 74 | PETRO | E.M.C. | INDSTRL | 134405 | 6352 | 14816 | 458 | 0 | 14896 | 110829 | 17.45 | 3.152 |
| 75 | PHY. PLNT. | U. OF M. | INDSTRL | 50608 | 7689 | 0 | 242 | 3211 | 4036 | 79749 | 10.37 | .854 |
| 76 | PLENTYWOOD | PLENTYWOOD | ARMORY | 8689 | 8911 | 0 | 23 | 983 | 1061 | 122122 | 13.70 | .225 |
| 77 | POOL | U. OF M. | MISC | 22630 | 7537 | 0 | 309 | 5062 | 6117 | 270289 | 35.86 | 1.294 |
| 78 | QUAD A&B | M.S.U. | DORMITORY | 13613 | 7537 | 0 | 28 | 743 | 840 | 61676 | 8.18 | .178 |
| 79 | QUAD C&D | M.S.U. | DORMITORY | 14945 | 7537 | 0 | 45 | 741 | 894 | 59806 | 7.94 | .189 |
| 80 | QUAD E&F | M.S.U. | DORMITORY | 13680 | 7537 | 0 | 41 | 701 | 842 | 61526 | 8.16 | .178 |
| 81 | REID | M.S.U. | OFFICE | 75107 | 7537 | 0 | 412 | 6563 | 7970 | 106119 | 14.08 | 1.687 |
| 82 | S.U.B. | M.S.U. | MPLX CNTR | 161317 | 7537 | 0 | 743 | 13328 | 15862 | 98328 | 13.05 | 3.357 |
| 83 | S.U.B. | N.M.C. | MPLX CNTR | 30015 | 7983 | 2361 | 50 | 0 | 2294 | 76435 | 9.57 | .486 |
| 84 | SCI. CMPLX | U. OF M. | CLASSROOM | 99051 | 7689 | 0 | 618 | 5963 | 8072 | 81490 | 10.60 | 1.708 |
| 85 | SCOTT HART | CAP. CMPLX | OFFICE | 76290 | 7766 | 5888 | 1057 | 0 | 8906 | 116739 | 15.03 | 1.885 |
| 86 | SER MAINT | HELENA | INDSTRL | 18815 | 7766 | 4540 | 158 | 0 | 4626 | 245893 | 31.66 | .979 |
| 87 | SIDNEY | SIDNEY | ARMORY | 8814 | 8244 | 1088 | 20 | 0 | 1048 | 118901 | 14.42 | .222 |
| 88 | TCHR RET | CAPITOL CO. | OFFICE | 6974 | 7766 | 399 | 66 | 0 | 586 | 84025 | 10.82 | .124 |
| 89 | TURNER | U. OF M. | OFFICE | 34796 | 7689 | 0 | 63 | 2047 | 2263 | 65033 | 8.46 | .479 |
| 90 | UNIV. CNTR | U. OF M. | MPLX CNTR | 179470 | 7689 | 0 | 2810 | 15114 | 24704 | 137650 | 17.90 | 5.228 |
| 91 | VEH. STRG | CHINOOK | GARAGE | 4784 | 7983 | 866 | 37 | 0 | 906 | 189376 | 23.72 | .192 |
| 92 | VEH. STRG | BILLINGS | GARAGE | 6656 | 6352 | 1662 | 28 | 0 | 1590 | 238855 | 37.60 | .336 |
| 93 | VET. HOME | COLMB FLS | APT CMPLX | 88658 | 8149 | 19984 | 543 | 0 | 19839 | 223768 | 27.46 | 4.199 |
| 94 | WHEAT APTS | HELENA | OFFICE | 5520 | 7766 | 705 | 17 | 0 | 691 | 125160 | 16.12 | .146 |
| 95 | WHITEFISH | WHITEFISH | ARMORY | 8000 | 8149 | 890 | 13 | 0 | 844 | 105561 | 12.95 | .179 |
| 96 | WILSON | M.S.U. | CLASSROOM | 84708 | 7537 | 0 | 824 | 7157 | 9968 | 117679 | 15.61 | 2.110 |

ALPHABETIC LISTING

| NO. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION | | | | USAGE OF ENERGY | | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | BTU/GSF /YR | BTU/GSF /DD | |
| 97 | WOMACK | FT. HARR. | ARMORY | 21820 | 7766 | 2544 | 57 | 0 | 2484 | 113850 | 14.66 | .526 |

# ENERGY USAGE LISTING
## LISTED IN DECREASING ORDER OF % OF TOTAL BUILDING ENERGY CONSUMED

| NO. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION | | | | USAGE OF ENERGY | | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | BTU/GSF /YR | BTU/GSF /DD | |
| 1 | HDGS CMPLX | M.S.U. | DORMITORY | 401569 | 7537 | 0 | 3801 | 37573 | 50544 | 125867 | 16.70 | 10.697 |
| 2 | UNIV. CNTR | U. OF M. | MPLX CNTR | 179470 | 7689 | 0 | 2810 | 15114 | 24704 | 137650 | 17.90 | 5.228 |
| 3 | VET. HOME | COLMB FLS | APT CMPLX | 88658 | 8149 | 19984 | 543 | 0 | 19839 | 223768 | 27.46 | 4.199 |
| 4 | COBLEIGH | M.S.U. | OFFICE | 92741 | 7537 | 0 | 845 | 15816 | 18701 | 201645 | 26.75 | 3.958 |
| 5 | CNTR F AGD | LEWISTOWN | APT CMPLX | 74764 | 8651 | 17651 | 487 | 0 | 17549 | 234721 | 27.13 | 3.714 |
| 6 | S.U.B. | M.S.U. | MPLX CNTR | 161317 | 7537 | 0 | 743 | 13328 | 15862 | 98328 | 13.05 | 3.357 |
| 7 | L. JOHNSON | M.S.U. | CLASSROOM | 112011 | 7537 | 0 | 545 | 13570 | 15432 | 137769 | 18.28 | 3.266 |
| 8 | PETRO | E.M.C. | INDSTRL | 134405 | 6352 | 14816 | 458 | 0 | 14896 | 110829 | 17.45 | 3.152 |
| 9 | LIBRARY | U. OF M. | CLASSROOM | 216558 | 7689 | 0 | 1802 | 8447 | 14598 | 67407 | 8.77 | 3.089 |
| 10 | FIELD HS. | M.S.U. | SPRT CMPL | 104600 | 7537 | 0 | 649 | 11301 | 13516 | 129213 | 17.14 | 2.860 |
| 11 | LIBRARY | M.S.U. | CLASSROOM | 152085 | 7537 | 0 | 2138 | 6144 | 13439 | 88367 | 11.72 | 2.844 |
| 12 | CRTV. ARTS | M.S.U. | CLASSROOM | 135012 | 7537 | 0 | 1690 | 6462 | 12230 | 90588 | 12.02 | 2.588 |
| 13 | WILSON | M.S.U. | CLASSROOM | 84708 | 7537 | 0 | 824 | 7157 | 9968 | 117679 | 15.61 | 2.110 |
| 14 | LANGFORD | M.S.U. | DORMITORY | 106399 | 7537 | 0 | 502 | 7607 | 9322 | 87615 | 11.62 | 1.973 |
| 15 | FIELD HS. | U. OF M. | SPRT CMPL | 169449 | 7689 | 0 | 384 | 7784 | 9094 | 53665 | 6.98 | 1.924 |
| 16 | MORGAN | N.M.C. | DORMITORY | 50938 | 7983 | 9357 | 178 | 0 | 9029 | 177264 | 22.21 | 1.911 |
| 17 | HAPNER | M.S.U. | DORMITORY | 94612 | 7537 | 0 | 535 | 7111 | 8937 | 94456 | 12.53 | 1.891 |
| 18 | SCOTT HART | CAP. CMPLX | OFFICE | 76290 | 7766 | 5888 | 1057 | 0 | 8906 | 116739 | 15.03 | 1.885 |
| 19 | LODGE | U. OF M. | MPLX CNTR | 85041 | 7689 | 0 | 872 | 5657 | 8633 | 101521 | 13.20 | 1.827 |
| 20 | CRG & DNWY | U. OF M. | DORMITORY | 110843 | 7689 | 0 | 402 | 7190 | 8563 | 77249 | 10.05 | 1.812 |
| 21 | ABER | U. OF M. | DORMITORY | 87951 | 7689 | 0 | 505 | 6836 | 8558 | 97303 | 12.65 | 1.811 |
| 22 | JESSE | U. OF M. | DORMITORY | 87951 | 7689 | 0 | 475 | 6835 | 8455 | 96138 | 12.50 | 1.789 |
| 23 | HANNON | M.S.U. | DORMITORY | 91011 | 7537 | 0 | 414 | 6767 | 8181 | 89891 | 11.93 | 1.731 |
| 24 | SCI. CMPLX | U. OF M. | CLASSROOM | 99051 | 7689 | 0 | 618 | 5963 | 8072 | 81490 | 10.60 | 1.708 |
| 25 | REID | M.S.U. | OFFICE | 75107 | 7537 | 0 | 412 | 6563 | 7970 | 106119 | 14.08 | 1.687 |
| 26 | CRBN-BRTLY | U. OF M. | DORMITORY | 73699 | 7689 | 0 | 222 | 7201 | 7960 | 108010 | 14.05 | 1.685 |
| 27 | MILLER | U. OF M. | DORMITORY | 64628 | 7689 | 0 | 328 | 6168 | 7286 | 112737 | 14.66 | 1.542 |
| 28 | POOL | U. OF M. | MISC | 22630 | 7537 | 0 | 309 | 5062 | 6117 | 270289 | 35.86 | 1.294 |
| 29 | KNOWLES | U. OF M. | DORMITORY | 67078 | 7689 | 0 | 235 | 5284 | 6085 | 90715 | 11.80 | 1.288 |
| 30 | E.S.C. | CAP CMPLX | OFFICE | 49621 | 7766 | 4525 | 580 | 0 | 6054 | 121998 | 15.71 | 1.281 |
| 31 | MRRD STDNT | N.M.C. | APT CMPLX | 37029 | 7983 | 5742 | 181 | 0 | 5784 | 156205 | 19.57 | 1.224 |
| 32 | HLN ARM. | HELENA | ARMORY | 48854 | 7766 | 4778 | 170 | 0 | 4879 | 99877 | 12.86 | 1.033 |

# ENERGY USAGE LISTING
## LISTED IN DECREASING ORDER OF % OF TOTAL BUILDING ENERGY CONSUMED

| NO. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION | | | | USAGE OF ENERGY | | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | BTU/GSF /YR | BTU/GSF /DD | |
| 33 | HEALTH SRV | U. OF M. | HOSPITAL | 34658 | 7689 | 0 | 332 | 3702 | 4837 | 139553 | 18.15 | 1.024 |
| 34 | AVTN MAINT | HELENA | INDSTRL | 17204 | 7766 | 4255 | 290 | 0 | 4820 | 280183 | 36.08 | 1.020 |
| 35 | SER MAINT | HELENA | INDSTRL | 18815 | 7766 | 4540 | 158 | 0 | 4626 | 245893 | 31.66 | .979 |
| 36 | PHY. PLNT. | U. OF M. | INDSTRL | 50608 | 7689 | 0 | 242 | 3211 | 4036 | 79749 | 10.37 | .854 |
| 37 | ELROD | U. OF M. | DORMITORY | 34323 | 7689 | 0 | 118 | 3347 | 3751 | 109288 | 14.21 | .794 |
| 38 | LVSTCK PVL | M.S.U. | MISC | 23607 | 7537 | 3809 | 85 | 0 | 3717 | 157466 | 20.89 | .787 |
| 39 | GREENHOUSE | M.S.U. | MISC | 16878 | 7537 | 0 | 232 | 2208 | 3000 | 177725 | 23.58 | .635 |
| 40 | WOMACK | FT. HARR. | ARMORY | 21820 | 7766 | 2544 | 57 | 0 | 2484 | 113850 | 14.66 | .526 |
| 41 | F&G HQ | HELENA | OFFICE | 31040 | 7766 | 1900 | 222 | 0 | 2467 | 79462 | 10.23 | .522 |
| 42 | KALISPELL | KALISPELL | ARMORY | 14664 | 8149 | 2489 | 58 | 0 | 2437 | 166214 | 20.40 | .516 |
| 43 | APSARUKE | E.M.C. | INDSTRL | 20119 | 6352 | 2212 | 104 | 0 | 2347 | 116647 | 18.36 | .497 |
| 44 | S.U.B. | N.M.C. | MPLX CNTR | 30015 | 7983 | 2361 | 50 | 0 | 2294 | 76435 | 9.57 | .486 |
| 45 | TURNER | U. OF M. | OFFICE | 34796 | 7689 | 0 | 63 | 2047 | 2263 | 65033 | 8.46 | .479 |
| 46 | BILLINGS | BILLINGS | ARMORY | 16260 | 6352 | 2277 | 51 | 0 | 2224 | 136757 | 21.53 | .471 |
| 47 | BOZEMAN | BOZEMAN | ARMORY | 28000 | 7537 | 2270 | 30 | 0 | 2147 | 76674 | 10.17 | .454 |
| 48 | MNTL HLTH | BILLINGS | OFFICE | 20000 | 6352 | 1373 | 143 | 0 | 1723 | 96151 | 13.56 | .365 |
| 49 | VEH. STRG | BILLINGS | GARAGE | 6656 | 6352 | 1662 | 28 | 0 | 1590 | 238855 | 37.60 | .336 |
| 50 | ANACONDA | ANACONDA | ARMORY | 10000 | 8164 | 1576 | 23 | 0 | 1498 | 149767 | 18.34 | .317 |
| 51 | BUTTE | BUTTE | ARMORY | 9155 | 9142 | 1526 | 29 | 0 | 1472 | 160818 | 17.59 | .312 |
| 52 | MALTA | MALTA | ARMORY | 9400 | 8472 | 1520 | 20 | 0 | 1438 | 152926 | 18.05 | .304 |
| 53 | GLENDIVE | GLENDIVE | ARMORY | 8814 | 7324 | 1199 | 35 | 0 | 1197 | 135780 | 18.54 | .253 |
| 54 | LEWISTOWN | LEWISTOWN | ARMORY | 9530 | 8651 | 1233 | 17 | 0 | 1169 | 122634 | 14.18 | .247 |
| 55 | KALIS-S.F. | KALISPELL | ARMORY | 3200 | 8149 | 1181 | 31 | 0 | 1167 | 364585 | 44.74 | .247 |
| 56 | DILLON | DILLON | ARMORY | 7780 | 7730 | 1239 | 12 | 0 | 1157 | 148723 | 19.24 | .245 |
| 57 | DEER LODGE | DEER LODGE | ARMORY | 7600 | 8617 | 0 | 33 | 1006 | 1119 | 147174 | 17.08 | .237 |
| 58 | HI. HANGER | HELENA | GARAGE | 7070 | 7766 | 1103 | 24 | 0 | 1076 | 152167 | 19.59 | .228 |
| 59 | PLENTYWOOD | PLENTYWOOD | ARMORY | 8689 | 8911 | 0 | 23 | 983 | 1061 | 122122 | 13.70 | .225 |
| 60 | SIDNEY | SIDNEY | ARMORY | 8814 | 8244 | 1088 | 20 | 0 | 1048 | 118901 | 14.42 | .222 |
| 61 | CHINOOK | CHINOOK | ARMORY | 9132 | 7983 | 1056 | 16 | 0 | 1006 | 110158 | 13.80 | .213 |
| 62 | GLASGOW | GLASGOW | ARMORY | 9400 | 8754 | 974 | 23 | 0 | 954 | 101485 | 11.59 | .202 |
| 63 | MILES CITY | MILES CITY | ARMORY | 7738 | 7357 | 915 | 25 | 0 | 911 | 117668 | 15.99 | .193 |
| 64 | VEH. STRG | CHINOOK | GARAGE | 4784 | 7983 | 866 | 37 | 0 | 906 | 189376 | 23.72 | .192 |

# ENERGY USAGE LISTING
## LISTED IN DECREASING ORDER OF % OF TOTAL BUILDING ENERGY CONSUMED

| NO. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | USAGE OF ENERGY BTU/GSF /YR | BTU/GSF /DD | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 65 | F&G HANGER | HELENA | GARAGE | 5600 | 7766 | 985 | 4 | 0 | 902 | 161029 | 20.74 | .191 |
| 66 | QUAD C&D | M.S.U. | DORMITORY | 14945 | 7537 | 0 | 45 | 741 | 894 | 59806 | 7.94 | .189 |
| 67 | WHITEFISH | WHITEFISH | ARMORY | 8000 | 8149 | 890 | 13 | 0 | 844 | 105561 | 12.95 | .179 |
| 68 | QUAD E&F | M.S.U. | DORMITORY | 13680 | 7537 | 0 | 41 | 701 | 842 | 61526 | 8.16 | .178 |
| 69 | QUAD A&B | M.S.U. | DORMITORY | 13613 | 7537 | 0 | 28 | 743 | 840 | 61676 | 8.18 | .178 |
| 70 | GRAIN LAB | GREAT FALLS | OFFICE | 5325 | 7511 | 671 | 55 | 0 | 790 | 148391 | 19.76 | .167 |
| 71 | HARLOWTON | HARLOWTON | ARMORY | 3200 | 7500 | 787 | 11 | 0 | 744 | 232611 | 31.01 | .158 |
| 72 | HAMILTON | HAMILTON | ARMORY | 9597 | 7288 | 742 | 19 | 0 | 733 | 76359 | 10.48 | .155 |
| 73 | WHEAT APTS | HELENA | OFFICE | 5520 | 7766 | 705 | 17 | 0 | 691 | 125160 | 16.12 | .146 |
| 74 | M.A.C. OPR | HELENA | INDSTRL | 8557 | 7766 | 614 | 24 | 0 | 636 | 74299 | 9.57 | .135 |
| 75 | DISP WHSE | MISSOULA | GARAGE | 4964 | 7689 | 581 | 28 | 0 | 619 | 124639 | 16.21 | .131 |
| 76 | TCHR RET | CAPITOL CO. | OFFICE | 6974 | 7766 | 399 | 66 | 0 | 586 | 84025 | 10.82 | .124 |
| 77 | F&G WHSE | HELENA | GARAGE | 4800 | 7766 | 579 | 17 | 0 | 578 | 120468 | 15.51 | .122 |
| 78 | F&G #2HQ | MISSOULA | OFFICE | 1832 | 7537 | 503 | 17 | 0 | 512 | 279474 | 37.08 | .108 |
| 79 | CNTRL WHSE | MISSOULA | GARAGE | 5112 | 7689 | 390 | 47 | 0 | 510 | 99848 | 12.99 | .108 |
| 80 | ORG. MAINT | BELGRADE | INDSTRL | 1944 | 8367 | 519 | 10 | 0 | 500 | 257368 | 30.76 | .106 |
| 81 | PET. STAT. | BILLINGS | OFFICE | 5360 | 6352 | 441 | 22 | 0 | 470 | 87731 | 13.81 | .100 |
| 82 | FRSTRY HQ. | MSLA - DNRC | OFFICE | 4954 | 7689 | 317 | 53 | 0 | 465 | 93902 | 12.21 | .098 |
| 83 | HI. PATROL | BUTTE | OFFICE | 2176 | 9142 | 387 | 27 | 0 | 442 | 202960 | 22.20 | .093 |
| 84 | FIRE EQUP. | MISSOULA | GARAGE | 3916 | 7689 | 412 | 10 | 0 | 403 | 103001 | 13.40 | .085 |
| 85 | F&G I&E | HELENA | OFFICE | 2304 | 7766 | 395 | 7 | 0 | 379 | 164310 | 21.16 | .080 |
| 86 | P.E.R.S. | CAP. CMPLX | OFFICE | 7200 | 7766 | 248 | 36 | 0 | 345 | 47879 | 6.17 | .073 |
| 87 | ORG. MAINT | CULBERTSON | INDSTRL | 2664 | 8700 | 0 | 12 | 287 | 329 | 123682 | 14.22 | .070 |
| 88 | GARRETT | HELENA | OFFICE | 2839 | 7766 | 286 | 8 | 0 | 285 | 100372 | 12.92 | .060 |
| 89 | F&G DRAFT | HELENA | OFFICE | 2136 | 7766 | 199 | 7 | 0 | 204 | 95407 | 12.29 | .043 |
| 90 | MC GREGOR | HELENA | OFFICE | 2197 | 7766 | 194 | 8 | 0 | 201 | 91411 | 11.77 | .043 |
| 91 | F&G #6HQ | GLASGOW | OFFICE | 1924 | 8754 | 185 | 10 | 0 | 200 | 104013 | 11.88 | .042 |
| 92 | NRSRY OFF | MISSOULA | OFFICE | 2800 | 7689 | 132 | 23 | 0 | 199 | 70932 | 9.23 | .042 |
| 93 | CNYN FRRY | HELENA | MISC | 650 | 7766 | 0 | 3 | 126 | 137 | 210034 | 27.05 | .029 |
| 94 | FIRE PREV | MISSOULA | GARAGE | 2700 | 7689 | 72 | 3 | 0 | 75 | 27862 | 3.62 | .016 |
| 95 | CRASH RESC | WYELLOWSTN | GARAGE | 3674 | 10641 | 0 | 8 | 20 | 48 | 13106 | 1.23 | .010 |
| 96 | F&G WHSE | HELENA | GARAGE | 6000 | 7766 | 0 | 3 | 0 | 9 | 1514 | .19 | .002 |

# ENERGY USAGE LISTING
## LISTED IN DECREASING ORDER OF % OF TOTAL BUILDING ENERGY CONSUMED

| NO. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION | | | | USAGE OF ENERGY | | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | BTU/GSF /YR | BTU/GSF /DD | |
| 97 | ANML SHLTR | HELENA | MISC | 408 | 7766 | 0 | 1 | 0 | 5 | 12397 | 1.60 | .001 |

# ENERGY USAGE LISTING
## LISTED IN DECREASING ORDER OF ENERGY USE PER FLOOR AREA PER DEGREE DAY

| NO. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | USAGE OF ENERGY BTU/GSF /YR | BTU/GSF /DD | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | KALIS-S.F. | KALISPELL | ARMORY | 3200 | 8149 | 1181 | 31 | 0 | 1167 | 364585 | 44.74 | .247 |
| 2 | VEH. STRG | BILLINGS | GARAGE | 6656 | 6352 | 1662 | 28 | 0 | 1590 | 238855 | 37.60 | .336 |
| 3 | F&G #2HQ | MISSOULA | OFFICE | 1832 | 7537 | 503 | 17 | 0 | 512 | 279474 | 37.08 | .108 |
| 4 | AVTN MAINT | HELENA | INDSTRL | 17204 | 7766 | 4255 | 290 | 0 | 4820 | 280183 | 36.08 | 1.020 |
| 5 | POOL | U. OF M. | MISC | 22630 | 7537 | 0 | 309 | 5062 | 6117 | 270289 | 35.86 | 1.294 |
| 6 | SER MAINT | HELENA | INDSTRL | 18815 | 7766 | 4540 | 158 | 0 | 4626 | 245893 | 31.66 | .979 |
| 7 | HARLOWTON | HARLOWTON | ARMORY | 3200 | 7500 | 787 | 11 | 0 | 744 | 232611 | 31.01 | .158 |
| 8 | ORG. MAINT | BELGRADE | INDSTRL | 1944 | 8367 | 519 | 10 | 0 | 500 | 257368 | 30.76 | .106 |
| 9 | VET. HOME | COLMB FLS | APT CMPLX | 88658 | 8149 | 19984 | 543 | 0 | 19839 | 223768 | 27.46 | 4.199 |
| 10 | CNTR F AGD | LEWISTOWN | APT CMPLX | 74764 | 8651 | 17651 | 487 | 0 | 17549 | 234721 | 27.13 | 3.714 |
| 11 | CNYN FRRY | HELENA | MISC | 650 | 7766 | 0 | 3 | 126 | 137 | 210034 | 27.05 | .029 |
| 12 | COBLEIGH | M.S.U. | OFFICE | 92741 | 7537 | 0 | 845 | 15816 | 18701 | 201645 | 26.75 | 3.958 |
| 13 | VEH. STRG | CHINOOK | GARAGE | 4784 | 7983 | 866 | 37 | 0 | 906 | 189376 | 23.72 | .192 |
| 14 | GREENHOUSE | M.S.U. | MISC | 16878 | 7537 | 0 | 232 | 2208 | 3000 | 177725 | 23.58 | .635 |
| 15 | MORGAN | N.M.C. | DORMITORY | 50938 | 7983 | 9357 | 178 | 0 | 9029 | 177264 | 22.21 | 1.911 |
| 16 | HI. PATROL | BUTTE | OFFICE | 2176 | 9142 | 387 | 27 | 0 | 442 | 202960 | 22.20 | .093 |
| 17 | BILLINGS | BILLINGS | ARMORY | 16260 | 6352 | 2277 | 51 | 0 | 2224 | 136757 | 21.53 | .471 |
| 18 | F&G I&E | HELENA | OFFICE | 2304 | 7766 | 395 | 7 | 0 | 379 | 164310 | 21.16 | .080 |
| 19 | LVSTCK PVL | M.S.U. | MISC | 23607 | 7537 | 3809 | 85 | 0 | 3717 | 157466 | 20.89 | .787 |
| 20 | F&G HANGER | HELENA | GARAGE | 5600 | 7766 | 985 | 4 | 0 | 902 | 161029 | 20.74 | .191 |
| 21 | KALISPELL | KALISPELL | ARMORY | 14664 | 8149 | 2489 | 58 | 0 | 2437 | 166214 | 20.40 | .516 |
| 22 | GRAIN LAB | GREAT FALLS | OFFICE | 5325 | 7511 | 671 | 55 | 0 | 790 | 148391 | 19.76 | .167 |
| 23 | HI. HANGER | HELENA | GARAGE | 7070 | 7766 | 1103 | 24 | 0 | 1076 | 152167 | 19.59 | .228 |
| 24 | MRRD STDNT | N.M.C. | APT CMPLX | 37029 | 7983 | 5742 | 181 | 0 | 5784 | 156205 | 19.57 | 1.224 |
| 25 | DILLON | DILLON | ARMORY | 7780 | 7730 | 1239 | 12 | 0 | 1157 | 148723 | 19.24 | .245 |
| 26 | GLENDIVE | GLENDIVE | ARMORY | 8814 | 7324 | 1199 | 35 | 0 | 1197 | 135780 | 18.54 | .253 |
| 27 | APSARUKE | E.M.C. | INDSTRL | 20119 | 6352 | 2212 | 104 | 0 | 2347 | 116647 | 18.36 | .497 |
| 28 | ANACONDA | ANACONDA | ARMORY | 10000 | 8164 | 1576 | 23 | 0 | 1498 | 149767 | 18.34 | .317 |
| 29 | L. JOHNSON | M.S.U. | CLASSROOM | 112011 | 7537 | 0 | 545 | 13570 | 15432 | 137769 | 18.28 | 3.266 |
| 30 | HEALTH SRV | U. OF M. | HOSPITAL | 34658 | 7689 | 0 | 332 | 3702 | 4837 | 139553 | 18.15 | 1.024 |
| 31 | MALTA | MALTA | ARMORY | 9400 | 8472 | 1520 | 20 | 0 | 1438 | 152926 | 18.05 | .304 |
| 32 | UNIV. CNTR | U. OF M. | MPLX CNTR | 179470 | 7689 | 0 | 2810 | 15114 | 24704 | 137650 | 17.90 | 5.228 |

# ENERGY USAGE LISTING
## LISTED IN DECREASING ORDER OF ENERGY USE PER FLOOR AREA PER DEGREE DAY

| NO. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | USAGE OF ENERGY BTU/GSF /YR | BTU/GSF /DD | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 33 | BUTTE | BUTTE | ARMORY | 9155 | 9142 | 1526 | 29 | 0 | 1472 | 160818 | 17.59 | .312 |
| 34 | PETRO | E.M.C. | INDSTRL | 134405 | 6352 | 14816 | 458 | 0 | 14896 | 110829 | 17.45 | 3.152 |
| 35 | FIELD HS. | M.S.U. | SPRT CMPL | 104600 | 7537 | 0 | 649 | 11301 | 13516 | 129213 | 17.14 | 2.860 |
| 36 | DEER LODGE | DEER LODGE | ARMORY | 7600 | 8617 | 0 | 33 | 1006 | 1119 | 147174 | 17.08 | .237 |
| 37 | HDGS CMPLX | M.S.U. | DORMITORY | 401569 | 7537 | 0 | 3801 | 37573 | 50544 | 125867 | 16.70 | 10.697 |
| 38 | DISP WHSE | MISSOULA | GARAGE | 4964 | 7689 | 581 | 28 | 0 | 619 | 124639 | 16.21 | .131 |
| 39 | WHEAT APTS | HELENA | OFFICE | 5520 | 7766 | 705 | 17 | 0 | 691 | 125160 | 16.12 | .146 |
| 40 | MILES CITY | MILES CITY | ARMORY | 7738 | 7357 | 915 | 25 | 0 | 911 | 117668 | 15.99 | .193 |
| 41 | E.S.C. | CAP CMPLX | OFFICE | 49621 | 7766 | 4525 | 580 | 0 | 6054 | 121998 | 15.71 | 1.281 |
| 42 | WILSON | M.S.U. | CLASSROOM | 84708 | 7537 | 0 | 824 | 7157 | 9968 | 117679 | 15.61 | 2.110 |
| 43 | F&G WHSE | HELENA | GARAGE | 4800 | 7766 | 579 | 17 | 0 | 578 | 120468 | 15.51 | .122 |
| 44 | SCOTT HART | CAP. CMPLX | OFFICE | 76290 | 7766 | 5888 | 1057 | 0 | 8906 | 116739 | 15.03 | 1.885 |
| 45 | MILLER | U. OF M. | DORMITORY | 64628 | 7689 | 0 | 328 | 6168 | 7286 | 112737 | 14.66 | 1.542 |
| 46 | WOMACK | FT. HARR. | ARMORY | 21820 | 7766 | 2544 | 57 | 0 | 2484 | 113850 | 14.66 | .526 |
| 47 | SIDNEY | SIDNEY | ARMORY | 8814 | 8244 | 1088 | 20 | 0 | 1048 | 118901 | 14.42 | .222 |
| 48 | ORG. MAINT | CULBERTSON | INDSTRL | 2664 | 8700 | 0 | 12 | 287 | 329 | 123682 | 14.22 | .070 |
| 49 | ELROD | U. OF M. | DORMITORY | 34323 | 7689 | 0 | 118 | 3347 | 3751 | 109288 | 14.21 | .794 |
| 50 | LEWISTOWN | LEWISTOWN | ARMORY | 9530 | 8651 | 1233 | 17 | 0 | 1169 | 122634 | 14.18 | .247 |
| 51 | REID | M.S.U. | OFFICE | 75107 | 7537 | 0 | 412 | 6563 | 7970 | 106119 | 14.08 | 1.687 |
| 52 | CRBN-BRTLY | U. OF M. | DORMITORY | 73699 | 7689 | 0 | 222 | 7201 | 7960 | 108010 | 14.05 | 1.685 |
| 53 | PET. STAT. | BILLINGS | OFFICE | 5360 | 6352 | 441 | 22 | 0 | 470 | 87731 | 13.81 | .100 |
| 54 | CHINOOK | CHINOOK | ARMORY | 9132 | 7983 | 1056 | 16 | 0 | 1006 | 110158 | 13.80 | .213 |
| 55 | PLENTYWOOD | PLENTYWOOD | ARMORY | 8689 | 8911 | 0 | 23 | 983 | 1061 | 122122 | 13.70 | .225 |
| 56 | MNTL HLTH | BILLINGS | OFFICE | 20000 | 6352 | 1373 | 143 | 0 | 1723 | 86151 | 13.56 | .365 |
| 57 | FIRE EQUP. | MISSOULA | GARAGE | 3916 | 7689 | 412 | 10 | 0 | 403 | 103001 | 13.40 | .085 |
| 58 | LODGE | U. OF M. | MPLX CNTR | 85041 | 7689 | 0 | 872 | 5657 | 8633 | 101521 | 13.20 | 1.827 |
| 59 | S.U.B. | M.S.U. | MPLX CNTR | 161317 | 7537 | 0 | 743 | 13328 | 15862 | 98328 | 13.05 | 3.357 |
| 60 | CNTRL WHSE | MISSOULA | GARAGE | 5112 | 7689 | 390 | 47 | 0 | 510 | 99848 | 12.99 | .108 |
| 61 | WHITEFISH | WHITEFISH | ARMORY | 8000 | 8149 | 890 | 13 | 0 | 844 | 105561 | 12.95 | .179 |
| 62 | GARRETT | HELENA | OFFICE | 2839 | 7766 | 286 | 8 | 0 | 285 | 100372 | 12.92 | .060 |
| 63 | HLN ARM. | HELENA | ARMORY | 48854 | 7766 | 4778 | 170 | 0 | 4879 | 99877 | 12.86 | 1.033 |
| 64 | ADER | U. OF M. | DORMITORY | 87951 | 7689 | 0 | 505 | 6836 | 8558 | 97303 | 12.65 | 1.811 |

# ENERGY USAGE LISTING
## LISTED IN DECREASING ORDER OF ENERGY USE PER FLOOR AREA PER DEGREE DAY

| NO. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | USAGE OF ENERGY BTU/GSF /YR | BTU/GSF /DD | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 65 | HAPNER | M.S.U. | DORMITORY | 94612 | 7537 | 0 | 535 | 7111 | 8937 | 94456 | 12.53 | 1.891 |
| 66 | JESSE | U. OF M. | DORMITORY | 87951 | 7689 | 0 | 475 | 6835 | 8455 | 96138 | 12.50 | 1.789 |
| 67 | F&G DRAFT | HELENA | OFFICE | 2136 | 7766 | 199 | 7 | 0 | 204 | 95407 | 12.29 | .043 |
| 68 | FRSTRY HQ. | MSLA - DNRC | OFFICE | 4954 | 7689 | 317 | 53 | 0 | 465 | 93902 | 12.21 | .098 |
| 69 | CRTV. ARTS | M.S.U. | CLASSROOM | 135012 | 7537 | 0 | 1690 | 6462 | 12230 | 90588 | 12.02 | 2.588 |
| 70 | HANNON | M.S.U. | DORMITORY | 91011 | 7537 | 0 | 414 | 6767 | 8181 | 89891 | 11.93 | 1.731 |
| 71 | F&G #6HQ | GLASGOW | OFFICE | 1924 | 8754 | 185 | 10 | 0 | 200 | 104013 | 11.88 | .042 |
| 72 | KNOWLES | U. OF M. | DORMITORY | 67078 | 7689 | 0 | 235 | 5284 | 6085 | 90715 | 11.80 | 1.288 |
| 73 | MC GREGOR | HELENA | OFFICE | 2197 | 7766 | 194 | 8 | 0 | 201 | 91411 | 11.77 | .043 |
| 74 | LIBRARY | M.S.U. | CLASSROOM | 152085 | 7537 | 0 | 2138 | 6144 | 13439 | 88367 | 11.72 | 2.844 |
| 75 | LANGFORD | M.S.U. | DORMITORY | 106399 | 7537 | 0 | 502 | 7607 | 9322 | 87615 | 11.62 | 1.973 |
| 76 | GLASGOW | GLASGOW | ARMORY | 9400 | 8754 | 974 | 23 | 0 | 954 | 101485 | 11.59 | .202 |
| 77 | TCHR RET | CAPITOL CO. | OFFICE | 6974 | 7766 | 399 | 66 | 0 | 586 | 84025 | 10.82 | .124 |
| 78 | SCI. CMPLX | U. OF M. | CLASSROOM | 99051 | 7689 | 0 | 618 | 5963 | 8072 | 81490 | 10.60 | 1.708 |
| 79 | HAMILTON | HAMILTON | ARMORY | 9597 | 7288 | 742 | 19 | 0 | 733 | 76359 | 10.48 | .155 |
| 80 | PHY. PLNT. | U. OF M. | INDSTRL | 50608 | 7689 | 0 | 242 | 3211 | 4036 | 79749 | 10.37 | .854 |
| 81 | F&G HQ | HELENA | OFFICE | 31040 | 7766 | 1900 | 222 | 0 | 2467 | 79462 | 10.23 | .522 |
| 82 | BOZEMAN | BOZEMAN | ARMORY | 28000 | 7537 | 2270 | 30 | 0 | 2147 | 76674 | 10.17 | .454 |
| 83 | CRG & DNWY | U. OF M. | DORMITORY | 110843 | 7689 | 0 | 402 | 7190 | 8563 | 77249 | 10.05 | 1.812 |
| 84 | S.U.B. | N.M.C. | MPLX CNTR | 30015 | 7983 | 2361 | 50 | 0 | 2294 | 76435 | 9.57 | .486 |
| 85 | M.A.C. OPR | HELENA | INDSTRL | 8557 | 7766 | 614 | 24 | 0 | 636 | 74299 | 9.57 | .135 |
| 86 | NRSRY OFF | MISSOULA | OFFICE | 2800 | 7689 | 132 | 23 | 0 | 199 | 70932 | 9.23 | .042 |
| 87 | LIBRARY | U. OF M. | CLASSROOM | 216558 | 7689 | 0 | 1802 | 8447 | 14598 | 67407 | 8.77 | 3.089 |
| 88 | TURNER | U. OF M. | OFFICE | 34796 | 7689 | 0 | 63 | 2047 | 2263 | 65033 | 8.46 | .479 |
| 89 | QUAD A&B | M.S.U. | DORMITORY | 13613 | 7537 | 0 | 28 | 743 | 840 | 61676 | 8.18 | .178 |
| 90 | QUAD E&F | M.S.U. | DORMITORY | 13680 | 7537 | 0 | 41 | 701 | 842 | 61526 | 8.16 | .178 |
| 91 | QUAD C&D | M.S.U. | DORMITORY | 14945 | 7537 | 0 | 45 | 741 | 894 | 59806 | 7.94 | .189 |
| 92 | FIELD HS. | U. OF M. | SPRT CMPL | 169449 | 7689 | 0 | 384 | 7784 | 9094 | 53665 | 6.98 | 1.924 |
| 93 | P.E.R.S. | CAP. CMPLX | OFFICE | 7200 | 7766 | 248 | 36 | 0 | 345 | 47879 | 6.17 | .073 |
| 94 | FIRE PREV | MISSOULA | GARAGE | 2700 | 7689 | 72 | 3 | 0 | 75 | 27862 | 3.62 | .016 |
| 95 | ANML SHLTR | HELENA | MISC | 408 | 7766 | 0 | 1 | 0 | 5 | 12397 | 1.60 | .001 |
| 96 | CRASH RESC | WYELLOWSTN | GARAGE | 3674 | 10641 | 0 | 8 | 20 | 48 | 13106 | 1.23 | .010 |

ENERGY USAGE LISTING
LISTED IN DECREASING ORDER OF ENERGY USE PER FLOOR AREA PER DEGREE DAY

| NO. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | USAGE OF ENERGY BTU/GSF /YR | BTU/GSF /DD | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 97 | F&G WHSE | HELENA | GARAGE | 6000 | 7766 | 0 | 3 | 0 | 9 | 1514 | .19 | .002 |

ENERGY USAGE LISTING FOR HOSPITAL BUILDINGS
LISTED IN DECREASING ORDER OF ENERGY USE PER FLOOR AREA PER DEGREE DAY

| NO. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION | | | | USAGE OF ENERGY | | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | BTU/GSF /YR | BTU/GSF /DD | |
| 1 | HEALTH SRV | U. OF M. | HOSPITAL | 34658 | 7689 | 0 | 332 | 3702 | 4837 | 139553 | 18.15 | 1.024 |
| | AVERAGE | | HOSPITAL | 34658 | | | | | | 139553 | 18.15 | |

ENERGY USAGE LISTING FOR CLASSROOM BUILDINGS
LISTED IN DECREASING ORDER OF ENERGY USE PER FLOOR AREA PER DEGREE DAY

| NO. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION | | | | USAGE OF ENERGY | | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | BTU/GSF /YR | BTU/GSF /DD | |
| 1 | L. JOHNSON | M.S.U. | CLASSROOM | 112011 | 7537 | 0 | 545 | 13570 | 15432 | 137769 | 18.28 | 3.266 |
| 2 | WILSON | M.S.U. | CLASSROOM | 84708 | 7537 | 0 | 824 | 7157 | 9968 | 117679 | 15.61 | 2.110 |
| 3 | CRTV. ARTS | M.S.U. | CLASSROOM | 135012 | 7537 | 0 | 1690 | 6462 | 12230 | 90588 | 12.02 | 2.588 |
| 4 | LIBRARY | M.S.U. | CLASSROOM | 152085 | 7537 | 0 | 2138 | 6144 | 13439 | 88367 | 11.72 | 2.844 |
| 5 | SCI. CMPLX | U. OF M. | CLASSROOM | 99051 | 7689 | 0 | 618 | 5963 | 8072 | 81490 | 10.60 | 1.708 |
| 6 | LIBRARY | U. OF M. | CLASSROOM | 216558 | 7689 | 0 | 1802 | 8447 | 14598 | 67407 | 8.77 | 3.089 |
| | AVERAGE | | CLASSROOM | 133238 | | | | | | 92240 | 12.96 | |

# ENERGY USAGE LISTING FOR OFFICE BUILDINGS
## LISTED IN DECREASING ORDER OF ENERGY USE PER FLOOR AREA PER DEGREE DAY

| NO. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | USAGE OF ENERGY BTU/GSF /YR | BTU/GSF /DD | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | F&G #2HQ | MISSOULA | OFFICE | 1832 | 7537 | 503 | 17 | 0 | 512 | 279474 | 37.08 | .108 |
| 2 | COBLEIGH | M.S.U. | OFFICE | 92741 | 7537 | 0 | 845 | 15816 | 18701 | 201645 | 26.75 | 3.958 |
| 3 | HI. PATROL | BUTTE | OFFICE | 2176 | 9142 | 387 | 27 | 0 | 442 | 202960 | 22.20 | .093 |
| 4 | F&G I&E | HELENA | OFFICE | 2304 | 7766 | 395 | 7 | 0 | 379 | 164310 | 21.16 | .080 |
| 5 | GRAIN LAB | GREAT FALLS | OFFICE | 5325 | 7511 | 671 | 55 | 0 | 790 | 148391 | 19.76 | .167 |
| 6 | WHEAT APTS | HELENA | OFFICE | 5520 | 7766 | 705 | 17 | 0 | 691 | 125160 | 16.12 | .146 |
| 7 | E.S.C. | CAP CMPLX | OFFICE | 49621 | 7766 | 4525 | 580 | 0 | 6054 | 121998 | 15.71 | 1.281 |
| 8 | SCOTT HART | CAP. CMPLX | OFFICE | 76290 | 7766 | 5888 | 1057 | 0 | 8906 | 116739 | 15.03 | 1.885 |
| 9 | REID | M.S.U. | OFFICE | 75107 | 7537 | 0 | 412 | 6563 | 7970 | 106119 | 14.08 | 1.687 |
| 10 | PET. STAT. | BILLINGS | OFFICE | 5360 | 6352 | 441 | 22 | 0 | 470 | 87731 | 13.81 | .100 |
| 11 | MNTL HLTH | BILLINGS | OFFICE | 20000 | 6352 | 1373 | 143 | 0 | 1723 | 86151 | 13.56 | .365 |
| 12 | GARRETT | HELENA | OFFICE | 2839 | 7766 | 286 | 8 | 0 | 285 | 100372 | 12.92 | .060 |
| 13 | F&G DRAFT | HELENA | OFFICE | 2136 | 7766 | 199 | 7 | 0 | 204 | 95407 | 12.29 | .043 |
| 14 | FRSTRY HQ. | MSLA - DNRC | OFFICE | 4954 | 7689 | 317 | 53 | 0 | 465 | 93902 | 12.21 | .098 |
| 15 | F&G #6HQ | GLASGOW | OFFICE | 1924 | 8754 | 185 | 10 | 0 | 200 | 104013 | 11.88 | .042 |
| 16 | MC GREGOR | HELENA | OFFICE | 2197 | 7766 | 194 | 8 | 0 | 201 | 91411 | 11.77 | .043 |
| 17 | TCHR RET | CAPITOL CO. | OFFICE | 6974 | 7766 | 399 | 66 | 0 | 586 | 84025 | 10.82 | .124 |
| 18 | F&G HQ | HELENA | OFFICE | 31040 | 7766 | 1900 | 222 | 0 | 2467 | 79462 | 10.23 | .522 |
| 19 | NRSRY OFF | MISSOULA | OFFICE | 2800 | 7689 | 132 | 23 | 0 | 199 | 70932 | 9.23 | .042 |
| 20 | TURNER | U. OF M. | OFFICE | 34796 | 7689 | 0 | 63 | 2047 | 2263 | 65033 | 8.46 | .479 |
| 21 | P.E.R.S. | CAP. CMPLX | OFFICE | 7200 | 7766 | 248 | 36 | 0 | 345 | 47879 | 6.17 | .073 |
| | AVERAGE | | OFFICE | 20626 | | | | | | 124328 | 18.69 | |

ENERGY USAGE LISTING FOR INDSTRL BUILDINGS
LISTED IN DECREASING ORDER OF ENERGY USE PER FLOOR AREA PER DEGREE DAY

| O. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | USAGE OF ENERGY BTU/GSF /YR | BTU/GSF /DD | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | AVTN MAINT | HELENA | INDSTRL | 17204 | 7766 | 4255 | 290 | 0 | 4820 | 280183 | 36.08 | 1.020 |
| 2 | SER MAINT | HELENA | INDSTRL | 18815 | 7766 | 4540 | 158 | 0 | 4626 | 245893 | 31.66 | .979 |
| 3 | ORG. MAINT | BELGRADE | INDSTRL | 1944 | 8367 | 519 | 10 | 0 | 500 | 257368 | 30.76 | .106 |
| 4 | APSARUKE | E.M.C. | INDSTRL | 20119 | 6352 | 2212 | 104 | 0 | 2347 | 116647 | 18.36 | .497 |
| 5 | PETRO | E.M.C. | INDSTRL | 134405 | 6352 | 14816 | 458 | 0 | 14896 | 110829 | 17.45 | 3.152 |
| 6 | ORG. MAINT | CULBERTSON | INDSTRL | 2664 | 8700 | 0 | 12 | 287 | 329 | 123682 | 14.22 | .070 |
| 7 | PHY. PLNT. | U. OF M. | INDSTRL | 50608 | 7689 | 0 | 242 | 3211 | 4036 | 79749 | 10.37 | .854 |
| 8 | M.A.C. OPR | HELENA | INDSTRL | 8557 | 7766 | 614 | 24 | 0 | 636 | 74299 | 9.57 | .135 |
| | AVERAGE | | INDSTRL | 31790 | | | | | | 126579 | 21.48 | |

ENERGY USAGE LISTING FOR DORMITORY BUILDINGS
LISTED IN DECREASING ORDER OF ENERGY USE PER FLOOR AREA PER DEGREE DAY

| NO. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | USAGE OF ENERGY BTU/GSF /YR | BTU/GSF /DD | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | MORGAN | N.M.C. | DORMITORY | 50938 | 7983 | 9357 | 178 | 0 | 9029 | 177264 | 22.21 | 1.911 |
| 2 | HDGS CMPLX | M.S.U. | DORMITORY | 401569 | 7537 | 0 | 3801 | 37573 | 50544 | 125867 | 16.70 | 10.697 |
| 3 | MILLER | U. OF M. | DORMITORY | 64628 | 7689 | 0 | 328 | 6168 | 7286 | 112737 | 14.66 | 1.542 |
| 4 | ELROD | U. OF M. | DORMITORY | 34323 | 7689 | 0 | 118 | 3347 | 3751 | 109288 | 14.21 | .794 |
| 5 | CRBN-BRTLY | U. OF M. | DORMITORY | 73699 | 7689 | 0 | 222 | 7201 | 7960 | 108010 | 14.05 | 1.685 |
| 6 | ADER | U. OF M. | DORMITORY | 87951 | 7689 | 0 | 505 | 6836 | 8558 | 97303 | 12.65 | 1.811 |
| 7 | HAPNER | M.S.U. | DORMITORY | 94612 | 7537 | 0 | 535 | 7111 | 8937 | 94456 | 12.53 | 1.891 |
| 8 | JESSE | U. OF M. | DORMITORY | 87951 | 7689 | 0 | 475 | 6835 | 8455 | 96138 | 12.50 | 1.789 |
| 9 | HANNON | M.S.U. | DORMITORY | 91011 | 7537 | 0 | 414 | 6767 | 8181 | 89891 | 11.93 | 1.731 |
| 10 | KNOWLES | U. OF M. | DORMITORY | 67078 | 7689 | 0 | 235 | 5284 | 6085 | 90715 | 11.80 | 1.288 |
| 11 | LANGFORD | M.S.U. | DORMITORY | 106399 | 7537 | 0 | 502 | 7607 | 9322 | 87615 | 11.62 | 1.973 |
| 12 | CRG & DNWY | U. OF M. | DORMITORY | 110843 | 7689 | 0 | 402 | 7190 | 8563 | 77249 | 10.05 | 1.812 |
| 13 | QUAD A&B | M.S.U. | DORMITORY | 13613 | 7537 | 0 | 28 | 743 | 840 | 61676 | 8.18 | .178 |
| 14 | QUAD E&F | M.S.U. | DORMITORY | 13680 | 7537 | 0 | 41 | 701 | 842 | 61526 | 8.16 | .178 |
| 15 | QUAD C&D | M.S.U. | DORMITORY | 14945 | 7537 | 0 | 45 | 741 | 894 | 59806 | 7.94 | .189 |
| | AVERAGE | | DORMITORY | 87549 | | | | | | 106033 | 14.56 | |

ENERGY USAGE LISTING FOR MPLX CNTR BUILDINGS
LISTED IN DECREASING ORDER OF ENERGY USE PER FLOOR AREA PER DEGREE DAY

| NO. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | USAGE OF ENERGY BTU/GSF /YR | BTU/GSF /DD | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | UNIV. CNTR | U. OF M. | MPLX CNTR | 179470 | 7689 | 0 | 2810 | 15114 | 24704 | 137650 | 17.90 | 5.228 |
| 2 | LODGE | U. OF M. | MPLX CNTR | 85041 | 7689 | 0 | 872 | 5657 | 8633 | 101521 | 13.20 | 1.827 |
| 3 | S.U.B. | M.S.U. | MPLX CNTR | 161317 | 7537 | 0 | 743 | 13328 | 15862 | 98328 | 13.05 | 3.357 |
| 4 | S.U.B. | N.M.C. | MPLX CNTR | 30015 | 7983 | 2361 | 50 | 0 | 2294 | 76435 | 9.57 | .486 |
| | AVERAGE | | MPLX CNTR | 113961 | | | | | | 112964 | 15.25 | |

ENERGY USAGE LISTING FOR APT CMPLX BUILDINGS
LISTED IN DECREASING ORDER OF ENERGY USE PER FLOOR AREA PER DEGREE DAY

| NO. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | USAGE OF ENERGY BTU/GSF /YR | BTU/GSF /DD | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | VET. HOME | COLMB FLS | APT CMPLX | 88658 | 8149 | 19984 | 543 | 0 | 19839 | 223768 | 27.46 | 4.199 |
| 2 | CNTR F AGD | LEWISTOWN | APT CMPLX | 74764 | 8651 | 17651 | 487 | 0 | 17549 | 234721 | 27.13 | 3.714 |
| 3 | MRRD STDNT | N.M.C. | APT CMPLX | 37029 | 7983 | 5742 | 181 | 0 | 5784 | 156205 | 19.57 | 1.224 |
| | AVERAGE | | APT CMPLX | 66817 | | | | | | 215372 | 26.27 | |

ENERGY USAGE LISTING FOR GARAGE BUILDINGS
LISTED IN DECREASING ORDER OF ENERGY USE PER FLOOR AREA PER DEGREE DAY

| NO. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | USAGE OF ENERGY BTU/GSF /YR | BTU/GSF /DD | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | VEH. STRG | BILLINGS | GARAGE | 6656 | 6352 | 1662 | 28 | 0 | 1590 | 238855 | 37.60 | .336 |
| 2 | VEH. STRG | CHINOOK | GARAGE | 4784 | 7983 | 866 | 37 | 0 | 906 | 189376 | 23.72 | .192 |
| 3 | F&G HANGER | HELENA | GARAGE | 5600 | 7766 | 985 | 4 | 0 | 902 | 161029 | 20.74 | .191 |
| 4 | HI. HANGER | HELENA | GARAGE | 7070 | 7766 | 1103 | 24 | 0 | 1076 | 152167 | 19.59 | .228 |
| 5 | DISP WHSE | MISSOULA | GARAGE | 4964 | 7689 | 581 | 28 | 0 | 619 | 124639 | 16.21 | .131 |
| 6 | F&G WHSE | HELENA | GARAGE | 4800 | 7766 | 579 | 17 | 0 | 578 | 120468 | 15.51 | .122 |
| 7 | FIRE EQUP. | MISSOULA | GARAGE | 3916 | 7689 | 412 | 10 | 0 | 403 | 103001 | 13.40 | .085 |
| 8 | CNTRL WHSE | MISSOULA | GARAGE | 5112 | 7689 | 390 | 47 | 0 | 510 | 99848 | 12.99 | .108 |
| 9 | FIRE PREV | MISSOULA | GARAGE | 2700 | 7689 | 72 | 3 | 0 | 75 | 27862 | 3.62 | .016 |
| 10 | CRASH RESC | WYELLOWSTN | GARAGE | 3674 | 10641 | 0 | 8 | 20 | 48 | 13106 | 1.23 | .010 |
| 11 | F&G WHSE | HELENA | GARAGE | 6000 | 7766 | 0 | 3 | 0 | 9 | 1514 | .19 | .002 |
| | AVERAGE | | GARAGE | 5025 | | | | | | 121510 | 22.69 | |

ENERGY USAGE LISTING FOR SPRT CMPLX BUILDINGS
LISTED IN DECREASING ORDER OF ENERGY USE PER FLOOR AREA PER DEGREE DAY

| NO. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION | | | | USAGE OF ENERGY | | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | BTU/GSF /YR | BTU/GSF /DD | |
| 1 | FIELD HS. | M.S.U. | SPRT CMPL | 104600 | 7537 | 0 | 649 | 11301 | 13516 | 129213 | 17.14 | 2.860 |
| 2 | FIELD HS. | U. OF M. | SPRT CMPL | 169449 | 7689 | 0 | 384 | 7784 | 9094 | 53665 | 6.98 | 1.924 |
| | AVERAGE | | SPRT CMPL | 137025 | | | | | | 82501 | 13.06 | |

ENERGY USAGE LISTING FOR ARMORY BUILDINGS
LISTED IN DECREASING ORDER OF ENERGY USE PER FLOOR AREA PER DEGREE DAY

| NO. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | USAGE OF ENERGY BTU/GSF /YR | BTU/GSF /DD | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | KALIS-S.F. | KALISPELL | ARMORY | 3200 | 8149 | 1181 | 31 | 0 | 1167 | 364585 | 44.74 | .247 |
| 2 | HARLOWTON | HARLOWTON | ARMORY | 3200 | 7500 | 787 | 11 | 0 | 744 | 232611 | 31.01 | .158 |
| 3 | BILLINGS | BILLINGS | ARMORY | 16260 | 6352 | 2277 | 51 | 0 | 2224 | 136757 | 21.53 | .471 |
| 4 | KALISPELL | KALISPELL | ARMORY | 14664 | 8149 | 2489 | 58 | 0 | 2437 | 166214 | 20.40 | .516 |
| 5 | DILLON | DILLON | ARMORY | 7780 | 7730 | 1239 | 12 | 0 | 1157 | 148723 | 19.24 | .245 |
| 6 | GLENDIVE | GLENDIVE | ARMORY | 8814 | 7324 | 1199 | 35 | 0 | 1197 | 135780 | 18.54 | .253 |
| 7 | ANACONDA | ANACONDA | ARMORY | 10000 | 8164 | 1576 | 23 | 0 | 1498 | 149767 | 18.34 | .317 |
| 8 | MALTA | MALTA | ARMORY | 9400 | 8472 | 1520 | 20 | 0 | 1438 | 152926 | 18.05 | .304 |
| 9 | BUTTE | BUTTE | ARMORY | 9155 | 9142 | 1526 | 29 | 0 | 1472 | 160818 | 17.59 | .312 |
| 10 | DEER LODGE | DEER LODGE | ARMORY | 7600 | 8617 | 0 | 33 | 1006 | 1119 | 147174 | 17.08 | .237 |
| 11 | MILES CITY | MILES CITY | ARMORY | 7738 | 7357 | 915 | 25 | 0 | 911 | 117668 | 15.99 | .193 |
| 12 | WOMACK | FT. HARR. | ARMORY | 21820 | 7766 | 2544 | 57 | 0 | 2484 | 113850 | 14.66 | .526 |
| 13 | SIDNEY | SIDNEY | ARMORY | 8814 | 8244 | 1088 | 20 | 0 | 1048 | 118901 | 14.42 | .222 |
| 14 | LEWISTOWN | LEWISTOWN | ARMORY | 9530 | 8651 | 1233 | 17 | 0 | 1169 | 122634 | 14.18 | .247 |
| 15 | CHINOOK | CHINOOK | ARMORY | 9132 | 7983 | 1056 | 16 | 0 | 1006 | 110158 | 13.80 | .213 |
| 16 | PLENTYWOOD | PLENTYWOOD | ARMORY | 8689 | 8911 | 0 | 23 | 983 | 1061 | 122122 | 13.70 | .225 |
| 17 | WHITEFISH | WHITEFISH | ARMORY | 8000 | 8149 | 890 | 13 | 0 | 844 | 105561 | 12.95 | .179 |
| 18 | HLN ARM. | HELENA | ARMORY | 48854 | 7766 | 4778 | 170 | 0 | 4879 | 99877 | 12.86 | 1.033 |
| 19 | GLASGOW | GLASGOW | ARMORY | 9400 | 8754 | 974 | 23 | 0 | 954 | 101485 | 11.59 | .202 |
| 20 | HAMILTON | HAMILTON | ARMORY | 9597 | 7288 | 742 | 19 | 0 | 733 | 76359 | 10.48 | .155 |
| 21 | BOZEMAN | BOZEMAN | ARMORY | 28000 | 7537 | 2270 | 30 | 0 | 2147 | 76674 | 10.17 | .454 |
| | AVERAGE | | ARMORY | 12364 | | | | | | 122042 | 17.08 | |

ENERGY USAGE LISTING FOR MISC BUILDINGS
LISTED IN DECREASING ORDER OF ENERGY USE PER FLOOR AREA PER DEGREE DAY

| NO. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | USAGE OF ENERGY BTU/GSF /YR | BTU/GSF /DD | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | POOL | U. OF M. | MISC | 22630 | 7537 | 0 | 309 | 5062 | 6117 | 270289 | 35.86 | 1.294 |
| 2 | CNYN FRRY | HELENA | MISC | 650 | 7766 | 0 | 3 | 126 | 137 | 210034 | 27.05 | .029 |
| 3 | GREENHOUSE | M.S.U. | MISC | 16878 | 7537 | 0 | 232 | 2208 | 3000 | 177725 | 23.58 | .635 |
| 4 | LVSTCK PVL | M.S.U. | MISC | 23607 | 7537 | 3809 | 85 | 0 | 3717 | 157466 | 20.89 | .787 |
| 5 | ANML SHLTR | HELENA | MISC | 408 | 7766 | 0 | 1 | 0 | 5 | 12397 | 1.60 | .001 |
| | AVERAGE | | MISC | 12835 | | | | | | 202190 | 28.63 | |

# E N E R G Y  A U D I T  S U M M A R Y  1977

GENERAL DATA:

| | |
|---|---|
| NUMBER OF INSTITUTIONS IN AUDIT | 97 |
| TOTAL GROSS FLOOR AREA (SQUARE FEET) | 4144214 |

BUILDING FUELS:

| | |
|---|---|
| NATURAL GAS CONSUMPTION (MCF) | 141543 |
| OTHER FUEL CONSUMPTION (MMBTU) | 246063 |

ELECTRICITY:

| | |
|---|---|
| ELECTRICAL CONSUMPTION (MKWH) | 29026 |

TOTAL ENERGY:

| | |
|---|---|
| TOTAL ENERGY CONSUMPTION (MMBTU) | 472518 |

ENERGY USAGE

| | | |
|---|---|---|
| BTU/GSF/YR | = | 114018 |
| BTU/GSF/DD | = | 17.03 |

ENERGY USAGE FOR ALL BUILDINGS
ALPHABETIC LISTING

| NO. | NAME | BUILDING NUMBER | BUILDING TYPE | BTU/ GSF-DD 1975 | BTU/ GSF-DD 1976 | % CHANGE FROM 1975 | BTU/ GSF-DD 1977 | % CHANGE FROM 1976 |
|---|---|---|---|---|---|---|---|---|
| 31 | BONNER | 490689 | EQUIP | 31.65 | 37.33 | 17.96% | 28.56 | -23.49% |
| 32 | BOULDER | 480031 | CDO | 19.39 | 21.95 | 13.23% | 22.28 | 1.50% |
| 33 | BOULDER | 480638 | LONG LINES | 5.98 | 8.89 | 48.67% | 7.55 | -15.09% |
| 34 | BOX ELDER | 470678 | MICROWAVE | 145.87 | 154.56 | 5.96% | 122.22 | -20.93% |
| 35 | BOZEMAN | 480050 | DIAL EXCHANGE | 12.86 | 13.68 | 6.35% | 10.75 | -21.42% |
| 35 | BOZEMAN | 480051 | BUS. OFF. THIS BLDG'S ENERGY CONSUMPTION & AREA ARE INCLUDED IN THE ABOVE BLDG. | | | | | |
| 36 | BOZEMAN | 480052 | BUS. OFF. | 0.00 | 0.00 | N/A | 0.00 | N/A |
| 37 | BOZEMAN | 480053 | GAR-STRM | 11.02 | 10.28 | - 6.71% | 9.21 | -10.37% |
| 38 | BOZEMAN HILL | 480603 | LONG LINES | 23.11 | 23.09 | - .09% | 25.34 | 9.73% |
| 39 | BRADY | 470050 | CDO | 12.86 | 14.67 | 14.04% | 13.96 | - 4.83% |
| 40 | BRIDGER | 450050 | CDO | 25.25 | 27.89 | 10.42% | 22.88 | -17.93% |
| 41 | BRIDGER | 450051 | GAR-STRM | 22.51 | 20.76 | - 7.80% | 19.67 | - 5.25% |
| 42 | BROADUS | 440040 | CDO | 23.80 | 29.99 | 26.00% | 29.55 | - 1.48% |
| 43 | BROCKTON | 440030 | CDO | 17.91 | 25.64 | 43.14% | 19.58 | -23.65% |
| 44 | BUTTE | 460070 | DIAL EXCHANGE | 16.63 | 20.78 | 24.98% | 16.06 | -22.72% |
| 45 | BUTTE | 460074 | GAR-STRM | 8.37 | 8.70 | 4.01% | 7.58 | -12.94% |
| 46 | BUTTE | 460695 | EQUIP | 19.71 | 33.26 | 68.71% | 27.70 | -16.71% |
| 47 | BUTTE SOUTH | 460080 | EQUIP | 33.50 | 38.91 | 16.14% | 42.21 | 8.49% |
| 48 | CARIN CREEK | 440605 | MICROWAVE | 94.85 | 94.84 | - .00% | 94.84 | .00% |
| 49 | CANYON FERRY | 480080 | EQUIP | 47.56 | 52.55 | 10.50% | 47.57 | - 9.48% |
| 50 | CARLTON | 490606 | MICROWAVE | 190.74 | 190.73 | - .00% | 190.74 | .00% |
| 51 | CASCADE | 470090 | CDO | 12.45 | 16.75 | 34.56% | 20.60 | 22.95% |
| 52 | CEDAR HILL | 460696 | EQUIP | 33.48 | 39.41 | 17.72% | 40.61 | 3.03% |
| 53 | CHARLO | 490619 | MICROWAVE | 36.23 | 41.91 | 15.67% | 45.13 | 7.69% |
| 54 | CHINOOK | 470619 | MICROWAVE | 181.06 | 141.17 | -22.03% | 140.12 | - .74% |
| 55 | CHOTEAU | 470110 | CDO | 17.09 | 15.15 | -11.39% | 17.08 | 12.79% |
| 56 | CHOTEAU | 470762 | LONG LINES | 11.49 | 16.05 | 39.73% | 15.98 | - .45% |
| 57 | CLANCY | 480060 | CDO | 18.95 | 22.71 | 19.84% | 21.40 | - 5.74% |
| 58 | CLYDE PARK | 480070 | CDO | 19.98 | 18.94 | - 5.21% | 18.77 | - .89% |
| 59 | COLSTRIP | 440050 | CDO | 15.71 | 18.95 | 20.61% | 16.30 | -14.01% |
| 60 | COLUMBUS | 450091 | CDO | 17.97 | 18.64 | 3.70% | 17.48 | - 6.22% |
| 60 | COLUMBUS | 450092 | GARAGE THIS BLDG'S ENERGY CONSUMPTION & AREA ARE INCLUDED IN THE ABOVE BLDG. | | | | | |

Figure 5.1

SECTION: 6. DESCRIPTION OF BUILDING LIFE CYCLE ANALYSIS

As noted in Section 4, a management tool is needed to determine the economic feasibility of a retrofit project. The tool gaining popularity in the building industry is the life cycle analysis. This technique involves comparing the economics of alternative solutions to an existing mode of operation or a primary design. In the case of the building surveys presented in Section 7, the alternative solutions investigated for each building are methods that reduce energy consumption in a building as compared against the existing building and its mode of operation.

The final results of the life cycle analysis' calculations are: 1. The present worth of the annual net savings of each alternative accumulated over the life of the building as compared to the existing building, and; 2. The number of years at which the accumulated present worth savings equals the total required present worth investment to implement the particular alternative, referred to as breakeven or payback on the investment. To accomplish this, the building energy usage is modeled with heating degree day and bin calculations and monthly base load consumptions, including the energy required for cooling, for each alternative. Savings generated by a specific alternative generally result due to lower energy consumption and lower operating costs.

As with any management tool, the procedure uses several bits of information to produce the end product of the life cycle analysis. These factors include such economic items as initial investment costs, mortgage costs, material salvage values, maintenance costs, replacement costs, tax rates, insurance costs, rate of return, economic life, energy costs and several respective categorical inflation rates. For the purpose of this study, the life cycle analysis was restricted to the following economic items: economic building life, rate of return,

maintenance costs, and its respective inflation rate, and fuel costs and its respective inflation rate. Economic items such as mortgage costs, material salvage value, tax rates, and insurance costs were not considered to be applicable for state-funded projects.

Replacement of equipment or material with specific lifetimes less than the economic building life, were not evaluated. In general, the assumption was made that if the alternative required replacement of existing equipment, the cost of replacement was included as a part of the total alternative cost. Subsequent replacement costs would generally occur if either the existing equipment remained in operation or if the alternative's equipment was used. However, any future replacement cost difference between the specific alternative and the existing building were evaluated and included within the analysis.

The remaining economic factors, initial investment costs, economic life, maintenance costs, rate of return, energy costs, and the respective applicable inflation rates, are used in the life cycle analysis for the building surveys listed in Section 7. The initial investment costs, or first costs, were generally derived from the most recent building cost estimating guidelines. Under specific conditions, local contractors were polled for costs and their average costs were used.

The economic building life was furnished by the Montana Department of Administration, Architecture and Engineering Division and is noted for each building in the respective survey. The maintenance costs were based on modeling the alternative's change in maintenance schedule and the associated labor costs. For the most part, the alternatives used in the building surveys required no significant maintenance increase or decrease. For the alternatives that did require a differential maintenance cost, the cost was entered in 1979 dollars and was inflated at the general inflation rate of 6%.

The rate of return, the rate at which a present value of money earns interest or the interest at which invested money is required to earn, was also a value that was obtained from the State Architecture and Engineering Division. The value used was 7%.

The final pertinent economic factor was the energy costs. Energy costs were broken down by the type of energy and the local serving utility. Of the surveyed buildings, only two utility companies were involved, the Montana Power Company and Montana-Dakota Utility Company. Three different types of energy were used by the surveyed buildings: 1. Electricity, common to all surveyed buildings; 2. Natural gas, and; 3. Steam, used by buildings that are connected to natural gas-fired steam producing plants.

Since all of the surveyed buildings used electricity under the Montana Power Company jurisdiction and since there is no proposed rate increase at this writing, the electrical rates currently in effect were used.

Buildings using natural gas in the Montana-Dakota Utility franchise were modeled using a rate structure with an increase of 60% over the existing September 1, 1977 rates. This yields a base rate of $6.40 for the service charge and $1.34 for each MCF of natural gas used. Although these rates were expected to be an average for 1979, as of January 3, 1979, the Montana-Dakota Utilities Company was granted a rate increase to a base rate of $10.00 and a usage rate of $1.66712 per MCF. Consequently, the surveyed building's under the Montana-Dakota Utility franchise exhibit very conservative life cycle results.

Natural gas rates for the Montana Power Company were based on the proposed 22% rate increase for the rates in effect on May 15, 1978. This increase yields an approximate rate schedule shown in Figure 6.1.

Costs of steam supplied by a central heating plant are partially derived from natural gas costs. Using information from the University of Montana and

NATURAL GAS RATE STRUCTURE FOR MODELING BUILDING
ENERGY COSTS UNDER MONTANA POWER COMPANY JURISDICTION

| | Volume | | Rate |
|---|---|---|---|
| First | 1 | MCF | $5.96/MCF |
| Next | 99 | MCF | $2.86/MCF |
| Next | 200 | MCF | $2.50/MCF |
| Next | 700 | MCF | $2.29/MCF |
| Next | 4,000 | MCF | $2.22/MCF |

Figure 6.1

Montana State University, the cost of steam supplied to a building depends upon the fuel cost, overhead cost for plant operation, and a system distribution cost (Ref. RUF Factor in Section 4). Breaking down the University's costs into their respective components, the fuel cost was increased by 22%, then the three components were combined to obtain a flat rate steam cost. Due to differing overhead costs, the flat rate varies from central power plant to central power plant.

After determining the base energy rates, an energy inflation rate needed to be derived. Since this is highly variable and controversial, two inflation rates were used to form a bracket around the likely real rates. For the low electric annual inflation rate, 7%, or 1% above the projected annual general inflation rate, was used; and 12%, or 6% above the projected annual general inflation rate, was used for the high electric annual inflation rate. Over the last two years electrical rates have increased nationally 16%.

Natural gas prices are bracketed by annual 9% and 12% inflation rates, 3% and 6% respectively, above the projected annual general inflation rate. For a comparison, natural gas has increased 30% nationally over the last two years. Steam inflation rates are based on a weighted figure using the bracketed natural gas inflation rate and the general inflation rate of 6% for operating costs. This resulted in an inflation bracket slightly lower than the 9% and 12% bracket for natural gas, but the values again vary from central steam plant to central steam plant and from building to building (due to differing economic lives.) When using bracketing fuel inflation rates, the life cycle analysis yields two sets of results, one for the high inflation rate and the other for the low inflation rate.

Since the value of many of the economic parameters are derived in part subjectively, a sensitivity analysis was performed to help in estimating trends

for different economic values. The sensitivity analysis involves performing a series of life cycle analyses on an existing building and a typical alternative that reduced both electrical consumption and heating fuel consumption. The life cycle analysis is computed for a range of values for a specific parameter while all other parameters are held constant. The series of graphs shown in Figure 6.2 through 6.4 are the results of a sensitivity analysis for each specific parameter excepting the first cost parameter.

Figure 6.2 demonstrates the effect of varying fuel inflation rates on the payback period, the time required to recover the expended capital for the given alternative. Although the fuel inflation rates vary over a 10 point range, the payback period variation is relatively small, a change of only three years. Due to the relatively large savings of steam energy over the electric for the alternative, a 7.6:1 ratio on a BTU basis, the steam inflation rate produces the greatest variation.

The Figure 6.3 graph varies the energy base costs to effect a payback change. The variation of the steam costs resulted in a relatively siginificant change in payback period. On the other hand, an electrical cost variation showed a relative insignificant payback period change. The relative insensitivity of payback period to electrical costs is again due, in most part, to the relative rates of energy savings between steam and electricity.

The remaining two variables, the rate of return and the maintenance inflation rate, are plotted for a 10 point rate range in Figure 6.4. The alternative used for only the maintenance inflation analysis is a different alternative from the one used in the other sensitivity analyses because the other alternative did not require an increase or decrease in maintenance cost. Consequently, an alternative that incurred a typical maintenance cost change was

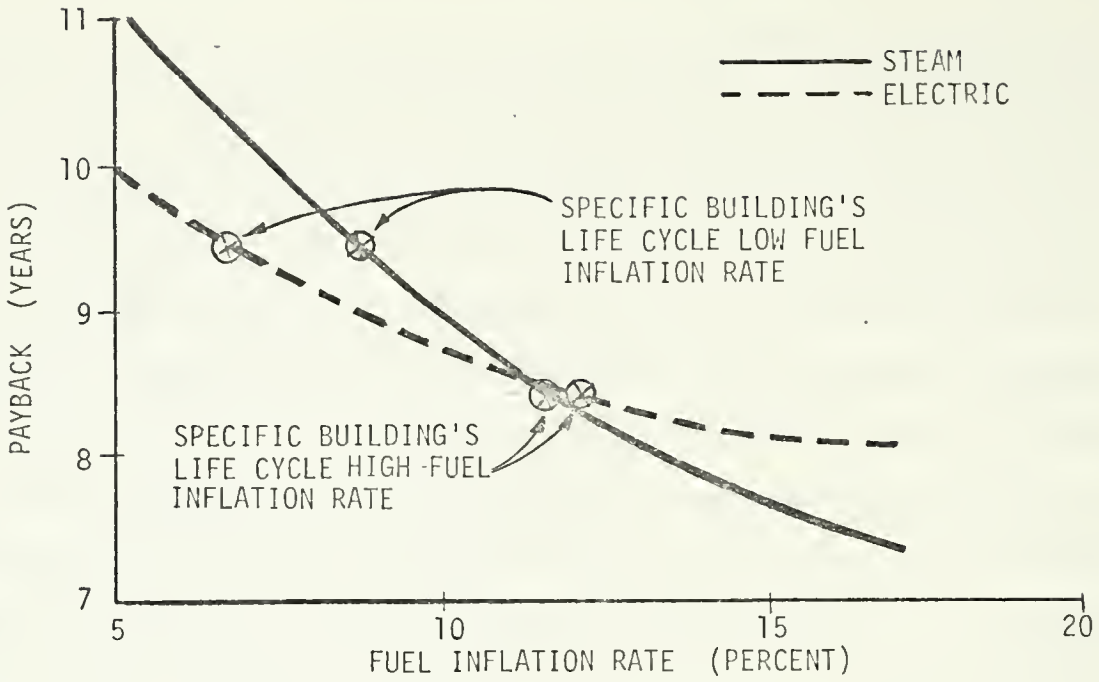



FIGURE 6.2 SENSITIVITY ANALYSIS OF FUEL INFLATION RATES

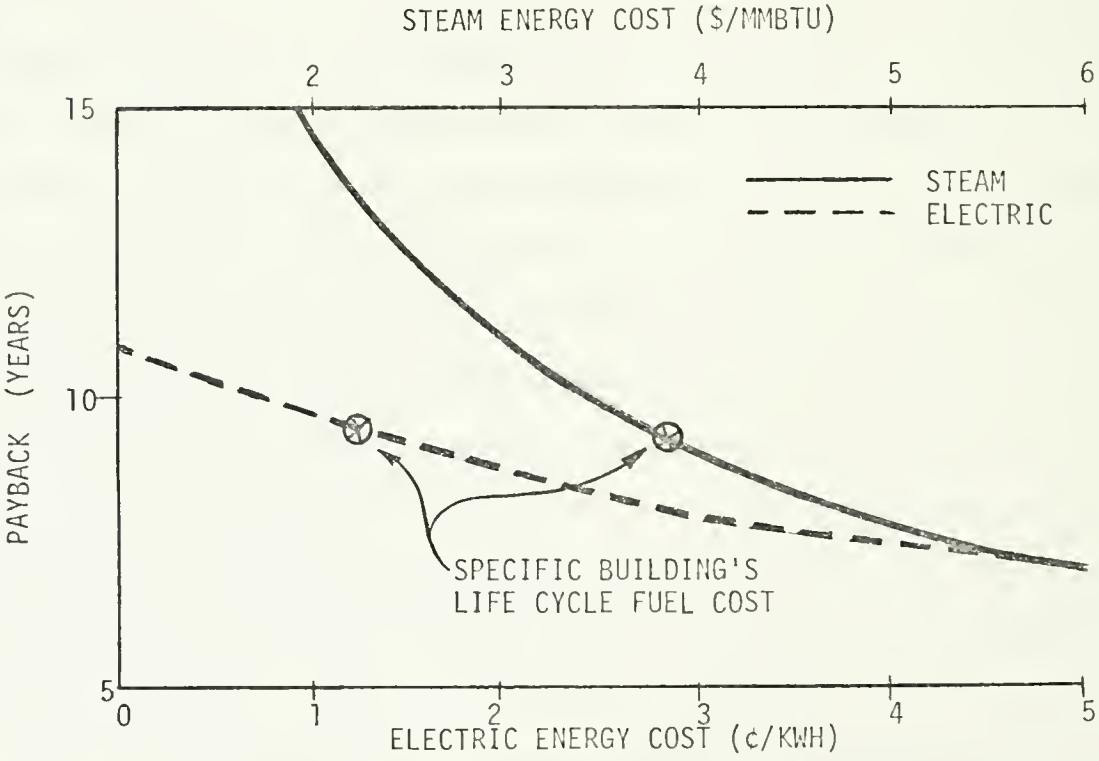



FIGURE 6.3 SENSITIVITY ANALYSIS OF FUEL BASE COSTS

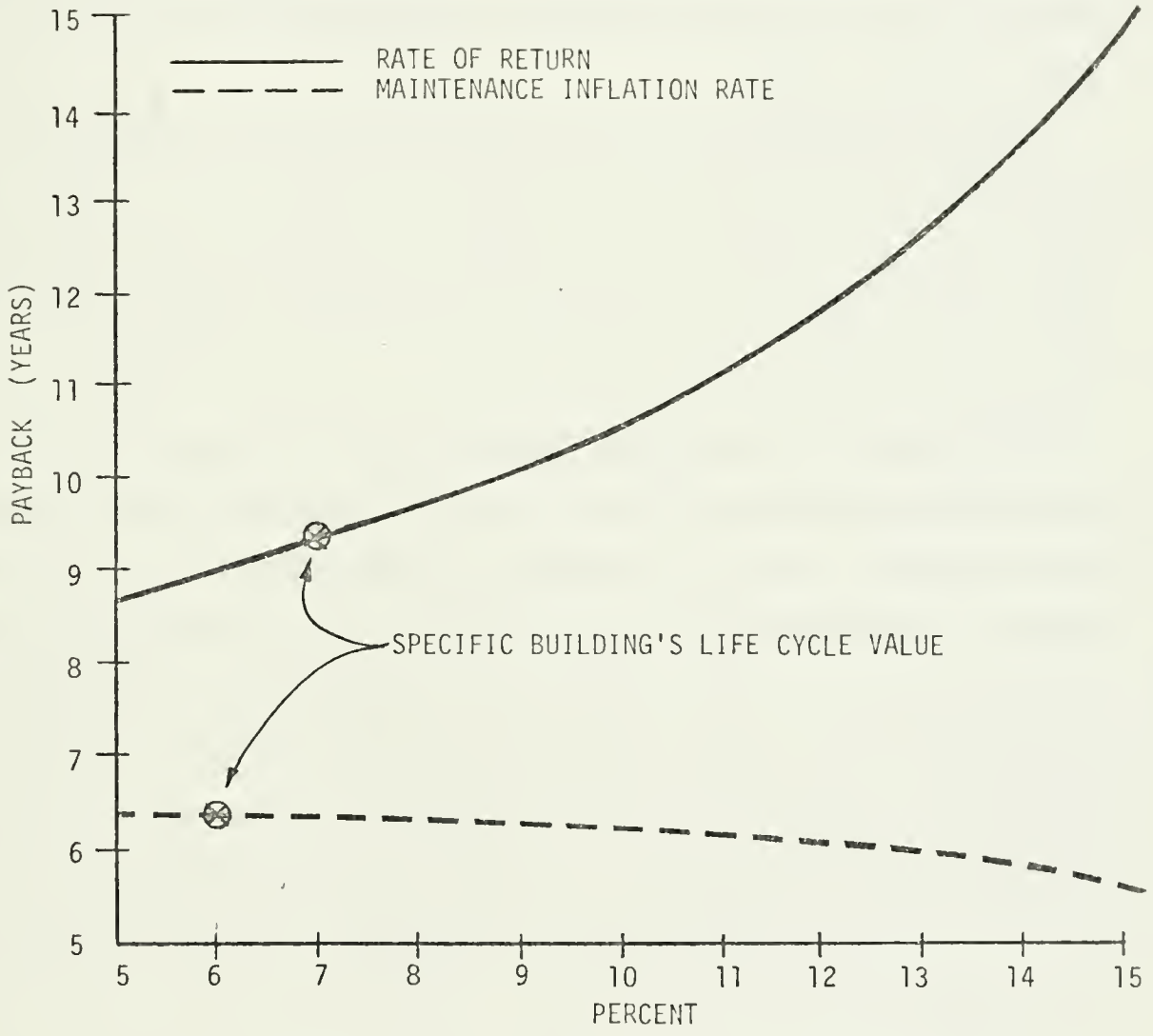



FIGURE 6.4 SENSITIVITY ANALYSIS OF RATE OF RETURN AND MAINTENANCE INFLATION RATE

substituted for analysis of the maintenance inflation rate. Upon analysis of the maintenance inflation rate curve, the rate variation negligibly varies the payback period.

In contrast, the other variable graphed in Figure 6.4, the rate of return, shows a marked increase in the payback period for an increase in the rate of return. This is a result of specifying a higher yield on invested monies with the rate of return.

As the graphs demonstrate, the payback period is relatively sensitive only to the base cost of the heating fuel and to the rate of return. Hence, a subjective error in determining either of these two parameters may produce a notable effect on the outcome of the life cycle analysis. For this reason, care was taken to minimize the subjective input.

The first sensitive parameter, base fuel costs, was based on existing fuel rates, requested rate increases, or in the case of MDU natural gas rates, rates that were estimated to be an average for 1979 based on past rate increases. The other sensitive parameter, the rate of return, was supplied by the Department of Administration via the Architect and Engineering Division. The department recommended that the State of Montana require 7% as the rate of return on an investment. However, if the State of Montana were able to earn or require a 9% rate of return (possible with available short-term certificates), the change in the payback period for this specific alternative is only an increase of one to two years.

SECTION: 7. INDIVIDUAL BUILDING SURVEYS
A. RETROFIT DESCRIPTION

This section consists of twenty individual building surveys that were completed by Drapes Engineering as part of this project. These buildings were surveyed for capital intensive energy saving options and analyzed using the life cycle economic analysis as described in Section 6. However, prior to presenting the formal building surveys, the following two sections, a detailed description of specific alternatives and survey format, are provided for clarification.

A. The next few paragraphs provide more specific information about energy saving options that occurred frequently throughout the twenty surveyed buildings. The following descriptions are divided into two categories, first a description of mechanical related retrofit options and second, a description of building envelope retrofit options.

Flue dampers were considered for use on most atmospheric burner boilers. The damper would operate in the open position while the boiler would be firing, and in the closed position while the boiler was not firing. Energy savings result due to eliminating the heat normally lost up the flue from the boiler vessel when the boiler is not firing.

Installing separate domestic water heaters were analyzed in buildings that used a boiler to provide building heat and domestic hot water. Installing a separate water heater allows the boiler to be shut-off during periods when the building doesn't require space heating, such as during the summer. Consequently boiler standby losses are eliminated, resulting in energy savings.

Other modifications to boilers included adding insulation to the boiler storage vessel. In most cases the surveyed boilers were either under or uninsulated. Adding insulation reduces the heat loss from the storage vessel. Currently, heat loss from an uninsulated boiler usually overheats the mechanical

room which then requires cooling. For similar reasons, insulating domestic hot water storage tanks were also analyzed.

Building temperature control modifications included analysis of installing night setback systems. The systems investigated incorporated a 15F$^{o}$ unoccupied temperature reduction during the heating season. The reduced building temperature results in lower envelope losses. In spite of the popular notion that a thermostat setback does not save energy due to reheating requirements, current research on instrumented buildings, indicate that savings do result, and are substantial.

Several heat recovery systems were analyzed. The type of building operation for which a heat recovery system was investigated was for buildings requiring massive amounts of exhausted air. The exhaust air in all cases had to be replaced in similar quantities with fresh air at the outside ambient temperature. As an energy saving option, the heat recovery system extracts heat from the exhausted air and releases the heat to the incoming cold fresh air.

In the case of the 20 surveyed buildings, the analyzed heat recovery systems required at minimum, two liquid-air heat exchangers, a pump, and a collecting-dissipating fluid. To collect the wasted heat, fluid is pumped through the heat exchanger positioned in the exhaust air stream where it absorbs heat; then the fluid is piped to the remotely located second heat exchanger positioned in the fresh air stream where it releases heat to the relatively cold air.

In nearly every building analyzed that uses a mechanical ventilation system a variable air volume (VAV) retrofit to the air handling units (AHU) was analyzed for saving energy. The VAV system reduces both heating energy and electrical energy requirements.

SECTION: 7. INDIVIDUAL BUILDING SURVEYS (CONT'D)
A. RETROFIT DESCRIPTION

Most single-zone systems under current operation, supply a variable amount of fresh and recirculated air to maintain a fixed mixed air temperature in order to provide full cooling during the cooling seasons referred to as "free cooling" or an economizer cycle. Generally the volume of fresh air introduced with the economizer for cooling greatly exceeds the minimum acceptable industry standards for fresh air under heating conditions. Consequently, due to the constant volume nature of the existing air handling unit operation, excessive amounts of fresh air are supplied to the building space during the heating season. Since the fresh air is at outside ambient temperatures, heat must be added to raise its temperature. Consequently, any excess fresh air requires extra heating energy. The remedy to this situation is to change the controls to introduce minimum fresh air during the heating mode. In addition, further savings are realized by reduced fan horsepower requirements through variable air volume fan operation.

For multizone systems the situation frequently occurs that an interior building zone with no adjacent exterior walls may require cooling due to internal heat gain from lights, people, etc., while a building zone with adjacent exterior walls may require heating. Consequently, because of the same control mode of providing "free cooling" by means of an economizer cycle, excess fresh air continues to be directed to the area requiring heating. The best method to reduce the energy waste is to reduce air flow to the zones that require heating. Therefore the VAV system varies the air volume suppled to each zone dependent upon the thermal requirements of the specific zone. If the zone is in a heating mode, the quantity of ventilation air is reduced to a minimum thus substantially reducing the volume of air that must be reheated.

If the zone heats up and eventually requires cooling, the quantity of ventilation is increased to provide for just the needed amount of cooling.

Therefore, a VAV system reduces the reheating of excess volumes of fresh air. Also as a consequence of reducing the ventilation rates, the velocity of air passing over an occupant's body is also reduced, thereby increasing the relative comfort of the individual with today's standard of 65$^{o}$F thermostat settings. The electrical savings result because the volume of air that is transported throughout the building is significantly reduced thereby reducing the fan power load. VAV operation was assumed to be achieved by fan speed modulation although other methods such as damper modulation can be used.

Envelope modifications generally involved building walls, roofs, windows and entrances. Primarily, insulation of walls and roofs involved determining the optimum insulation thickness. The procedure to calculate the optimum thickness of insulation is essentially an abbreviated life cycle analysis based on the cost of energy in the form of heat that is conducted through a particular building wall or roof and the total cost to insulate the wall or roof with various insulation thicknesses which would reduce the conducted heat loss. Figure 7.1 graphs the annual operation cost of a square foot of wall surface with various thicknesses of additional insulation. The thickness of insulation that results in the minimum annual cost is referred to as the economic optimum thickness of insulation. The life cycle economic data used for the optimum insulation thickness calculations is the same as described in Section 6. This analysis is sensitive to the existing thermal resistivity of the wall so every alternative in the individual building's life cycle analysis study, where a wall or roof was considered for insulating, was subjected to the optimum insulation life cycle calculation. The original thermal resistivity of the wall used to develop Figure 7.1 was 3.26 HR-SF-F$^{o}$/BTU, typical of most surveyed buildings.

Windows were analyzed for replacing the window area with insulating walls and/or installing new thermopaned windows. Safety and ventilation requirements were satisfied with the proposed window modification for each surveyed building.

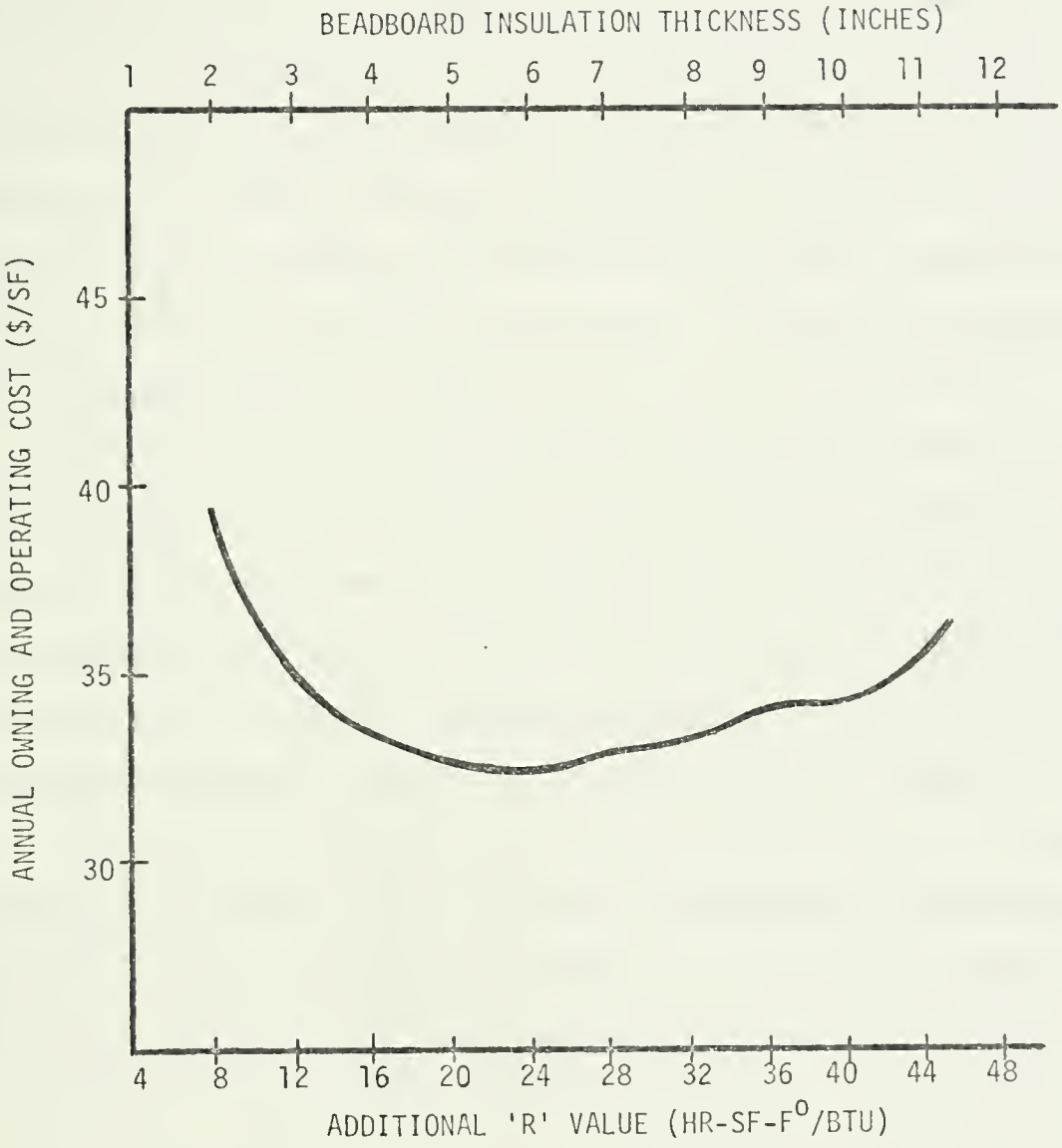

BEADBOARD INSULATION THICKNESS (INCHES)
1 2 3 4 5 6 7 8 9 10 11 12
ANNUAL OWNING AND OPERATING COST ($/SF)
45
40
35
30
4 8 12 16 20 24 28 32 36 40 44 48
ADDITIONAL 'R' VALUE (HR-SF-F°/BTU)

FIGURE 7.1 OPTIMUM ADDITIONAL INSULATION THICKNESS FOR AN EXISTING WALL WITH 'R' = 3.26

Generally, window modification required some sections being blocked and insulated and the remaining glass being double or triple-glazed. Usually a percentage of window area blocked and a percentage of double or triple-glazed window areas are used to describe the extent of the modification.

Another envelope modification consisted of analyzing the feasibility of installing a vestibule on the building entrances. A vestibule, an entrance using two sets of doors to form an isolated air volume, reduces the rate at which heated or cooled air is lost from a building.

B. The following 20 building surveys follows a predetermined presentation format for each building to provide for easy reference and comparisons.

The first main subsection, 1., is the building description. Within this section is: a general description of the building layout, usage, and age; a building envelope description consisting of wall and roof construction and existing insulation; and a heating, ventilation and air-conditioning system description which identifies the air handling units, and the heating and cooling systems.

Subsection 2 describes the various alternatives that were investigated with the life cycle energy analysis procedure. Following the list of alternatives is a series of unscaled floor plans and elevations on which the general location of the specific alternative is shown in the building. Following the drawings is the life cycle cost summary table. This table enumerates for each alternative the estimated first cost or initial capital expenditure, the bracketed present worth of the net life cycle savings in thousands of dollars, the corresponding bracketed breakeven time period for the total capital cost (Ref. Section 6 for explanation of bracketed fuel inflation rates), the resultant total building energy savings, and the resultant average year's building energy

utilization index (EUI). When analyzing the present worth of the life cycle cost figures, recognize that this represents the net dollar savings of the alternative, i.e. the total alternative cost has already been deducted, via the appropriate economic calculations, from the table figure. Consequently, any positive present worth of life cycle cost savings figure indicates a retrofit alternative that results in a reduced life cycle cost over the present building life cycle cost. Any negative present worth of life cycle cost savings figure indicates a retrofit alternative that results in a higher life cycle cost than the present building life cycle cost.

The last subsection, 3., is a listing of alternatives in order of priority for accomplishing energy conservation and reducing life cycle costs. This section reenumerates the alternative's energy savings, the first cost investment, and the payback period. Alternatives that require payback periods greater than the economic life for both fuel inflation bracket values are not recommended for further development or investigation on the specific building.

A computer printout, a part of the building surveys but bound separately, forms Appendix 4 of this report. The computer printout displays the economic analysis of each investigated alternative for each building. Appendix 3 is an interpretative guide for the computer printouts.

C. APSARUKE HALL

1. BUILDING DESCRIPTION

a. General

Apsaruke Hall was built in 1958 with three floors covering 20,119 square feet. The first floor contains supervisory living quarters, office space, lobby area, and infirmary in addition to dormitory rooms. The upper two floors are dormitory space.

b. Building Envelope

The built-up roof has 1.5 inches of rigid insulation. Walls are uninsulated eight inch block with four inch face brick. Windows are single glazed. Vestibules are not provided.

c. Heating, Ventilation, and Air-Conditioning System

There is no mechanical cooling in the building. Heating is provided by perimeter radiation. Cabinet heaters and convectors supply heat for corridors and stairways. A unit ventilator provides heat and fresh air for the lounge. Hot water for the heating system is supplied by a natural gas fired boiler.

2. LIFE CYCLE ENERGY ANALYSIS

a. Description of Alternatives

The following are energy conserving alternatives that were investigated for Apsaruke Hall.

Alternative #1

This alternative is the existing building "as is". Alternative #1 is the basis of comparison for the other alternatives.

2. LIFE CYCLE ENERGY ANALYSIS (CONTINUED)

Alternative #2

Install night setback controls for the dormitory rooms (Zones Three and Four).

Alternative #3

Install dampers in boiler and domestic water heater flues to reduce stand-by losses.

Alternative #4

Insulate the exterior wall with five inches of beadboard with stucco finish. This alternative includes blocking some of the window area; 50% of the lobby windows and 100% of toilet, laundry, and storage area windows.

Alternative #5

Replace single pane windows that aren't blocked with double glazed windows.

Alternative #6

Add four inches of beadboard to the existing 1.5 inches of rigid roof insulation when reroofing.

Alternative #7

Add inner doors at major entries to reduce infiltration.

b. Life Cycle Cost Summary

Table 7.2 is a summary of the Life Cycle Cost Analysis of each alternative showing the estimated first cost, the present worth of life cycle cost savings, the breakeven point (payback of first cost) in years, the percent

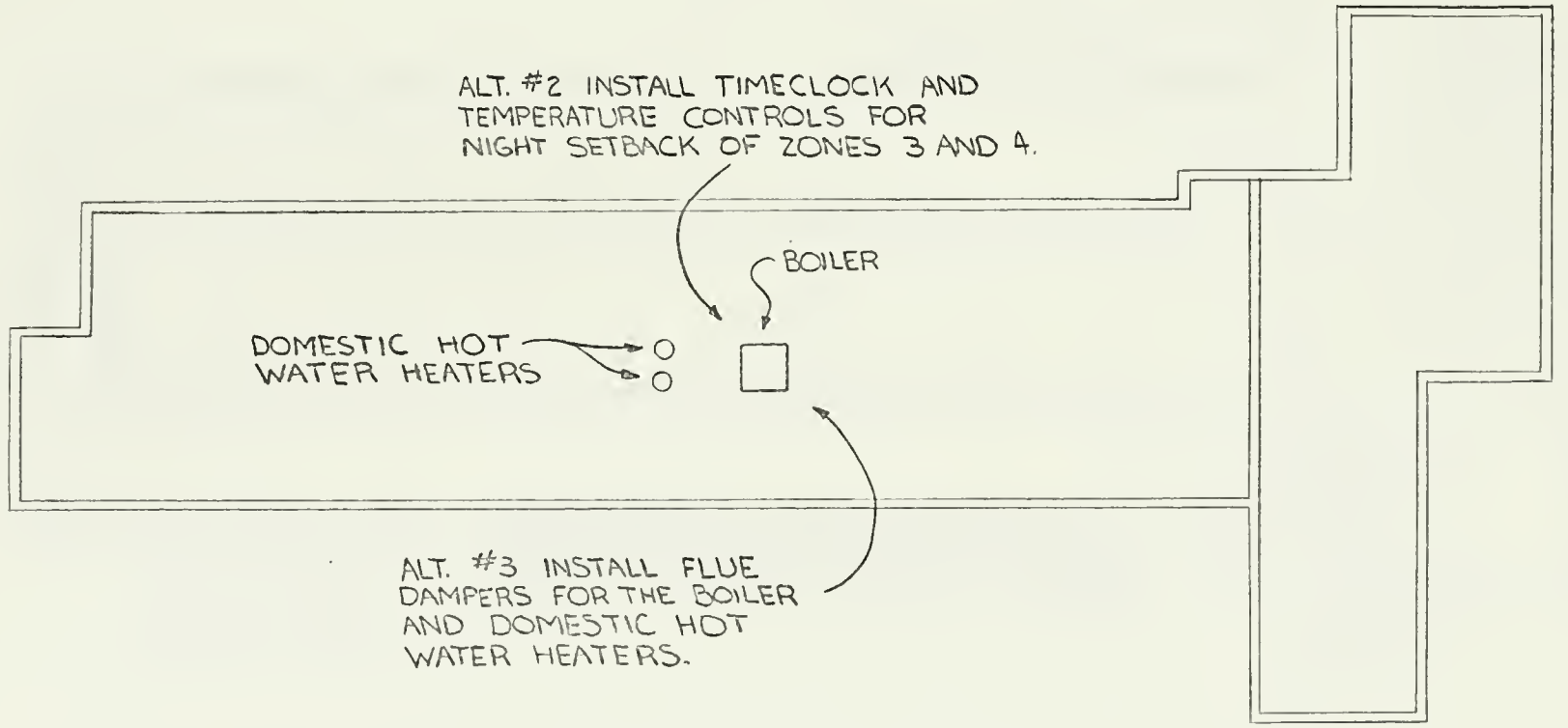
2. LIFE CYCLE ENERGY ANALYSIS (CONTINUED)

energy savings, and the energy use in BTU/gross square foot of building area/degree day for each alternative.

E.M.C. APSARUKE HALL
FOUNDATION PLAN
BILLINGS, MONTANA

DRAPES ENGINEERING
MECHANICAL & ELECTRICAL ENGINEERS
GREAT FALLS, MONTANA

DATE
SHEET 5
OF




# PARTIAL FOUNDATION PLAN

E.M.C. APSARUKE HALL
FIRST FLOOR PLAN
BILLINGS, MONTANA

DRAPES ENGINEERING
MECHANICAL & ELECTRICAL ENGINEERS
GREAT FALLS, MONTANA

DATE 11/16/72
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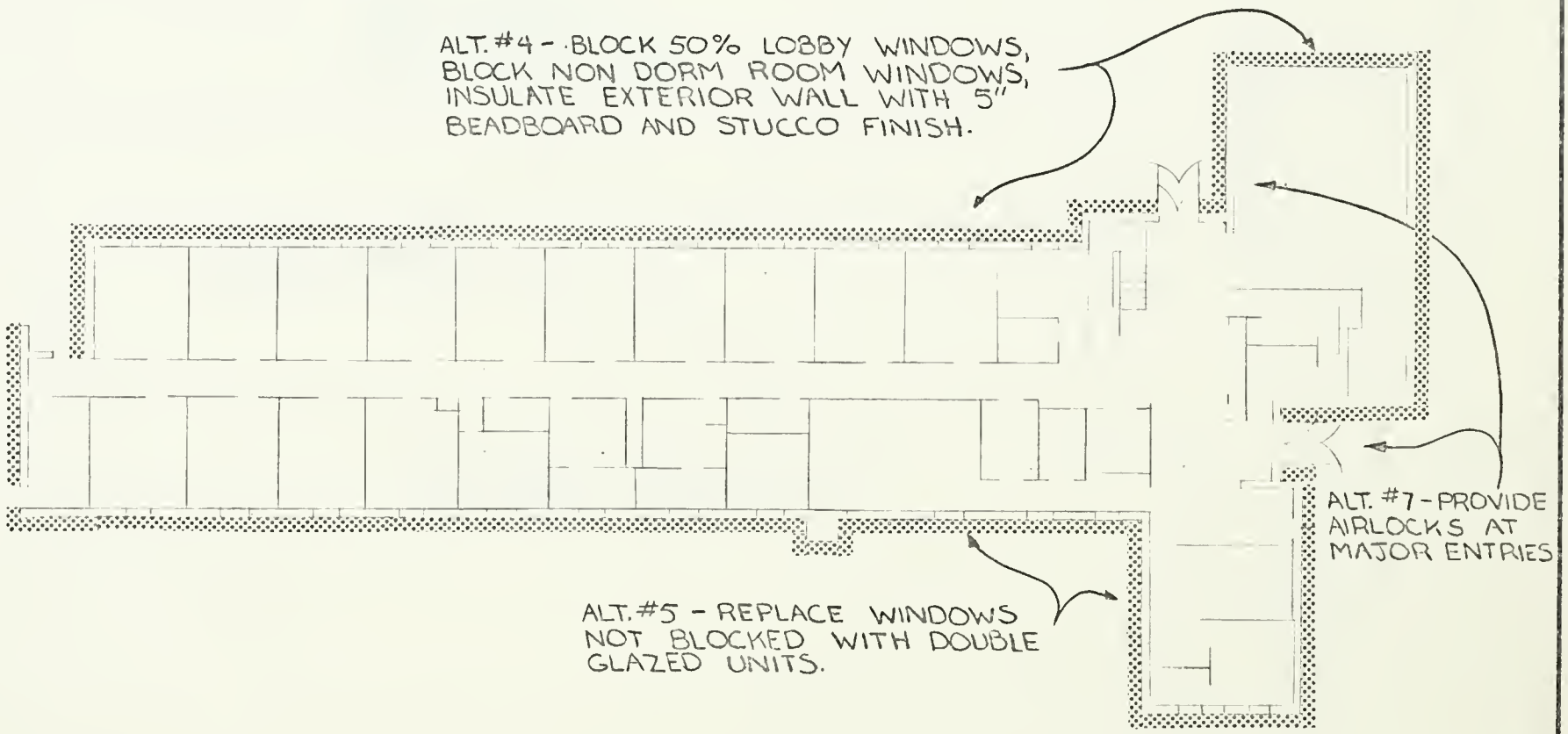
7.12

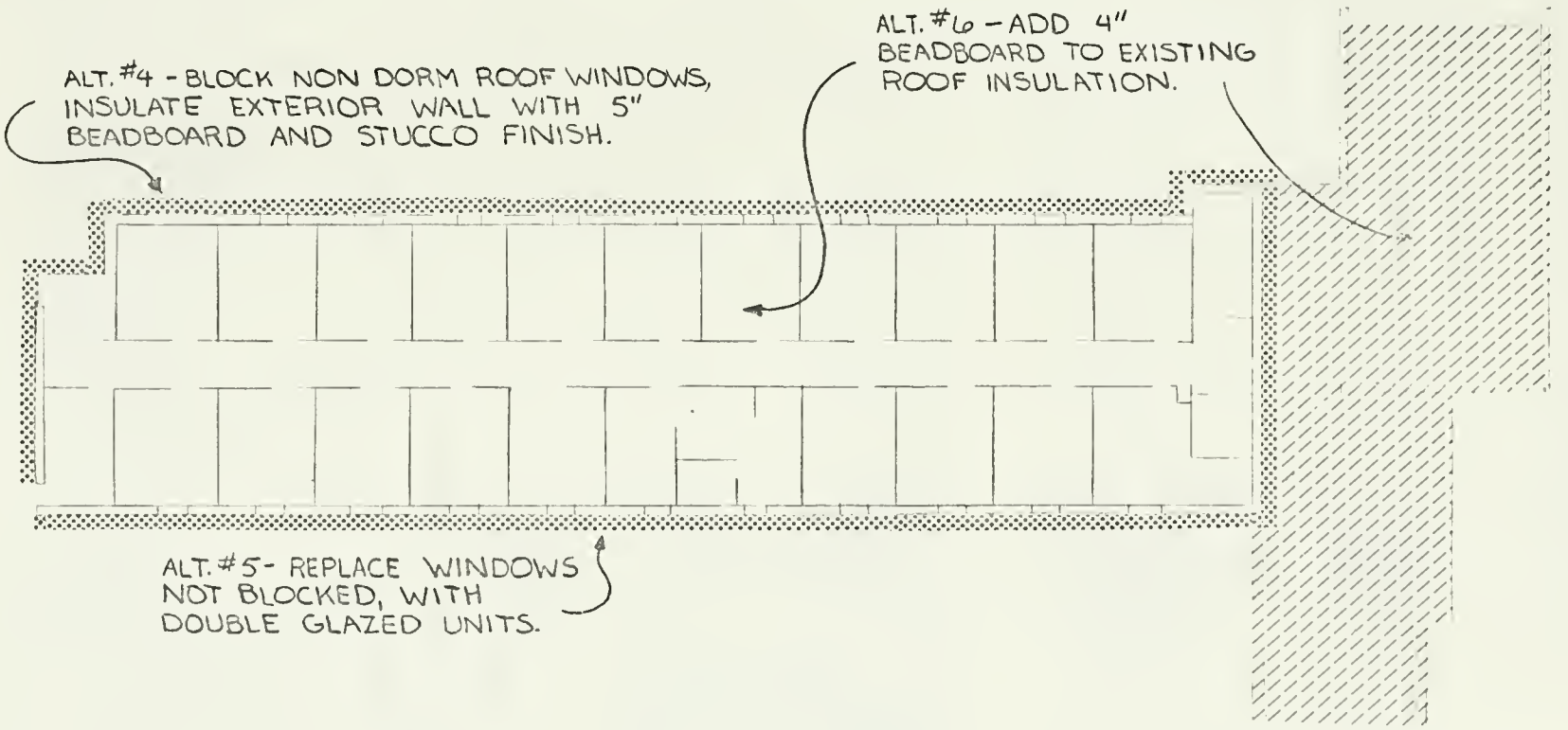

ALT. #4 - BLOCK 50% LOBBY WINDOWS, BLOCK NON DORM ROOM WINDOWS, INSULATE EXTERIOR WALL WITH 5" BEADBOARD AND STUCCO FINISH.
ALT. #7 - PROVIDE AIRLOCKS AT MAJOR ENTRIES
ALT. #5 - REPLACE WINDOWS NOT BLOCKED WITH DOUBLE GLAZED UNITS.

# FIRST FLOOR PLAN

E.M.C. APSARUKE HALL
SECOND AND THIRD FLR. PLAN
BILLINGS, MONTANA

DRAPES ENGINEERING
MECHANICAL & ELECTRICAL ENGINEERS
GREAT FALLS, MONTANA

DATE 11/1/73
SHEET 2 OF 3


ALT. #4 - BLOCK NON DORM ROOF WINDOWS, INSULATE EXTERIOR WALL WITH 5" BEADBOARD AND STUCCO FINISH.
ALT. #6 - ADD 4" BEADBOARD TO EXISTING ROOF INSULATION.
ALT. #5 - REPLACE WINDOWS NOT BLOCKED, WITH DOUBLE GLAZED UNITS.

# SECOND AND THIRD FLOOR PLAN

TABLE 7.2

LIFE CYCLE COST SUMMARY

APSARUKE HALL

| Alt. | Alternative Description | First Cost ($1000's) | Present Worth of Life Cycle Cost Savings ($1000's) | | Breakeven On First Cost (Yr) | | Percent Energy Savings | EUI BTU/GSF-DD |
|---|---|---|---|---|---|---|---|---|
| | | | Min. | Max. | Min. | Max. | | |
| 1 | Existing Building | - | - | - | - | - | - | 18.11 |
| 2 | Install Night Setback Controls | 1.7 | 6 | 12 | 9 | 10 | 4.5 | 17.29 |
| 3 | Install Flue Dampers | 2.9 | 1 | 4 | 22 | 28 | 2.2 | 17.71 |
| 4 | Insulate Exterior Wall and Block Windows | 39 | 10 | 46 | 23 | 30 | 27.5 | 13.12 |
| 5 | Double Glaze Windows | 27 | -19 | -13 | > 35 | > 35 | 4.6 | 17.27 |
| 6 | Add Roof Insulation | 5.5 | 6 | 15 | 16 | 19 | 6.7 | 16.90 |
| 7 | Add Inner Doors at Major Entries | 3.0 | -.4 | 2 | 29 | > 35 | 1.5 | 17.84 |

3. LIFE CYCLE CONSERVATION RECOMMENDATIONS

a. The following recommendations, in order of priority, are to conserve energy and reduce the Life Cycle owning and operating costs of the Montana Aeronautics Commission.

1. Alternative #2

Install night setback controls for the dormitory rooms. Estimated energy savings are 4.5% with a payback of 9 to 10 years for an investment of $1,715.00.

2. Alternative #6

Add four inches of beadboard to existing roof insulation when re-roofing. Estimated energy savings are 6.7% with a payback of 16 to 19 years for an investment of $5,473.00.

3. Alternative #3

Install flue dampers. Estimated energy savings are 2.2% with a payback of 22 to 28 years for an investment of $2,858.00.

4. Alternative #4

Insulate the exterior wall with five inches of beadboard. Block and insulate some of the windows. Estimated energy savings are 27.5% with a payback of 23 to 30 years for an investment of $39,322.00.

5. Alternative #7

Add inner doors at major entries to reduce infiltration. Estimated energy savings are 1.5% with a payback of 29 years to no payback for an investment of $3,036.00.

## D. PETRO HALL

### 1. BUILDING DESCRIPTION

#### a. General

Petro Hall was built in 1965 with eight floors covering 134,405 square feet. The first floor contains the auditorium and bookstore, along with lounge and exhibit areas. The remainder of the first floor is allotted to storage and the boiler room. The second floor contains the infirmary, lounge area, mail room, game room, living quarters, storage, and mechanical rooms. The upper six floors are dormitory space. The north side of the first floor is the only part of the building below grade.

#### b. Building Envelope

The built-up roof has 1.5 inches of rigid insulation. The ten inch cavity wall contains two inches of loose fill insulation. Windows are single glazed. Major entry doors have vestibules to reduce infiltration.

#### c. Heating, Ventilation and Air-Conditioning System

Rooftop units supply cooling for the first floor and the infirmary portion of the second floor. Mechanical cooling is not provided for the rest of the building.

Perimeter radiation supplies heat for all the floors. Multizone units provide fresh air, interior heating, and cooling for the first two floors. Single zone heating and ventilating units supply 100% fresh air to the dormitory corridors. Steam for the heating system is supplied by natural gas fired boilers.

2. LIFE CYCLE ENERGY ANALYSIS

a. Description of Alternatives

The following are energy conserving alternatives that were investigated for Petro Hall.

Alternative #1

This alternative is the existing building "as is". Alternative #1 is the basis of comparison for the other alternatives.

Alternative #2

Install dampers in boiler flues to reduce stand-by losses.

Alternative #3

Block and insulate 60% of the glass area. This alternative assumes five inches of beadboard with stucco finish in place of existing single pane glass.

Alternative #4

Add insulation when the existing roof is replaced. This alternative considers four inches of beadboard in addition to the existing 1.5 inches of rigid insulation.

Alternative #5

Reduce ventilation and exhaust rates for the dormitory floors by installing smaller fans.

Alternative #6

Reduce ventilation and exhaust rates for first and second floors by installing smaller exhaust fans and reducing the minimum fresh air settings on the supply units.

2. LIFE CYCLE ENERGY ANALYSIS (CONTINUED)

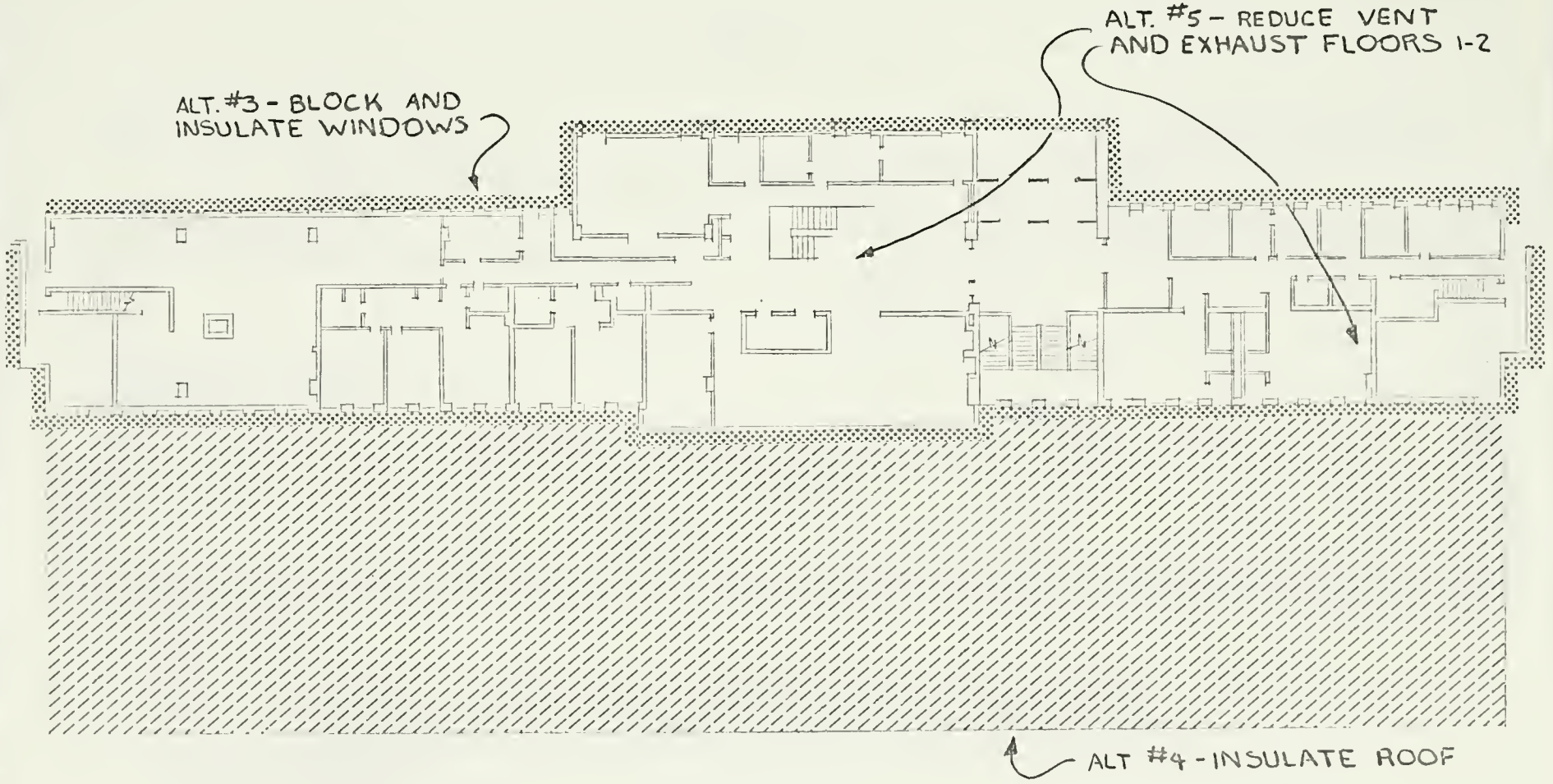
b. Life Cycle Cost Summary

Table 7.3is a summary of the Life Cycle Cost Analysis of each alternative showing the estimated first cost, the present worth of life cycle cost savings, the breakeven point (payback of first cost) in years, the percent energy savings, and the energy use in BTU/gross square foot of building area/degree day for each alternative.

E.M.C. PETRO RESIDENCE HALL
SECOND FLOOR PLAN
BILLINGS, MONTANA

DRAPES ENGINEERING
MECHANICAL & ELECTRICAL ENGINEERS
GREAT FALLS, MONTANA

DATE
SHEET 2
OF 3



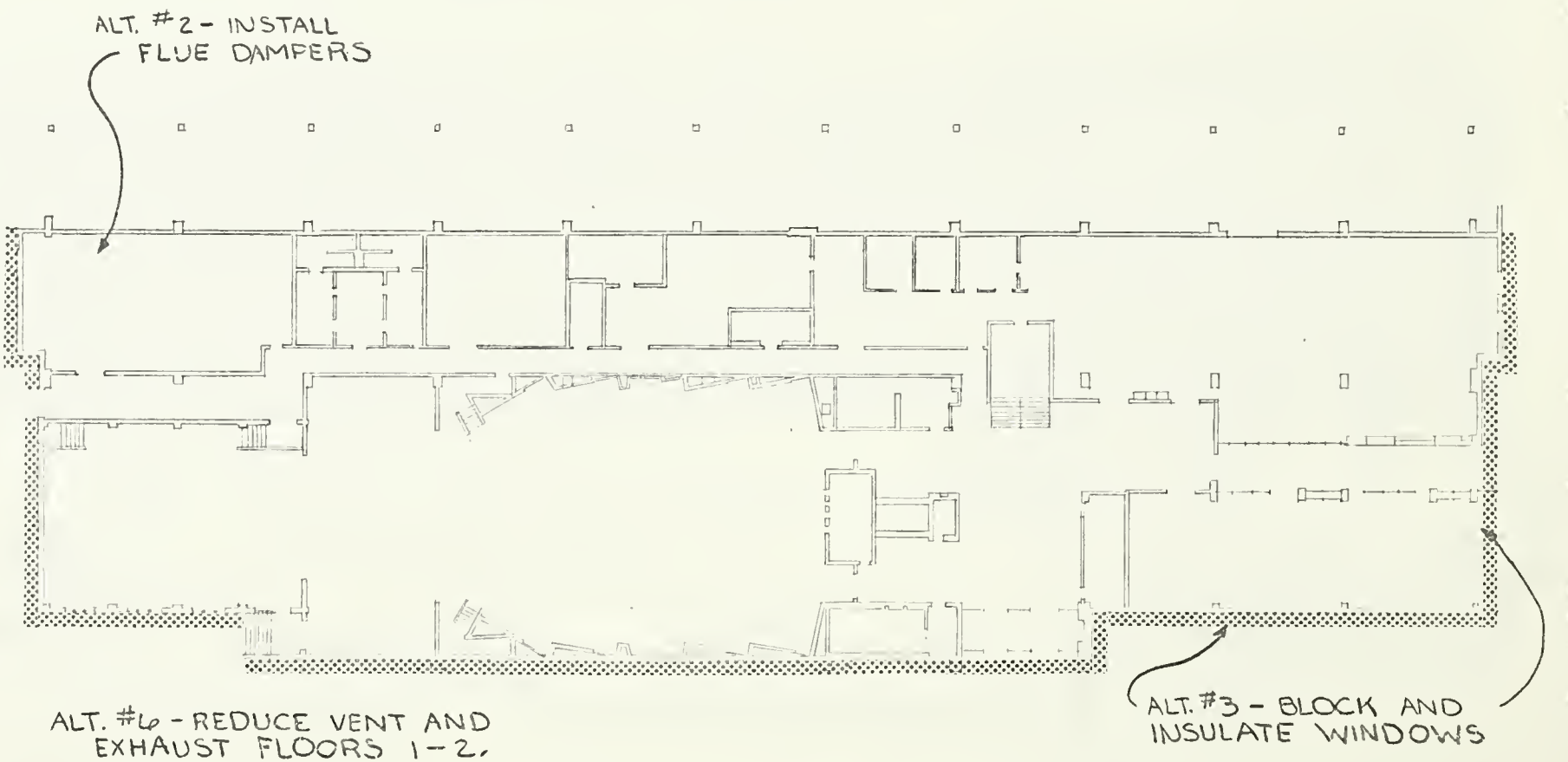

# SECOND FLOOR PLAN

7.20

EM.C. PETRO RESIDENCE HALL
FIRST FLOOR PLAN
BILLINGS, MONTANA

DRAPES ENGINEERING
MECHANICAL & ELECTRICAL ENGINEERS
GREAT FALLS, MONTANA

DATE
SHEET 2 OF 3

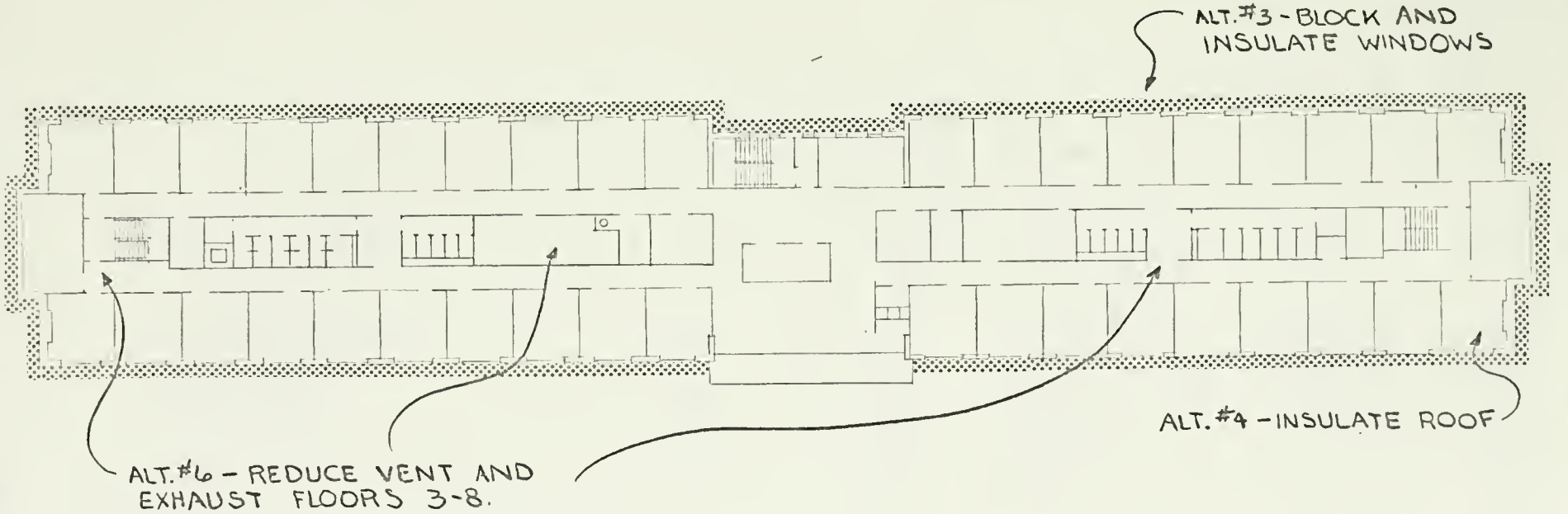



# FIRST FLOOR PLAN

E.M.C. PETRO RESIDENCE HALL
THIRD THROUGH EIGHTH FLOOR PLAN
BILLINGS, MONTANA

DRAPES ENGINEERING
MECHANICAL & ELECTRICAL ENGINEERS
GREAT FALLS, MONTANA

DATE 11/20/81
SHEET 3 OF 3




# THIRD THROUGH EIGHTH FLOOR PLAN

TABLE 7.3

LIFE CYCLE COST SUMMARY

PETRO HALL

| Alt. | Alternative Description | First Cost ($1000's) | Present Worth of Life Cycle Cost Savings ($1000's) | | Breakeven On First Cost (Yr) | | Percent Energy Savings | EUI BTU/GSF-DD |
|---|---|---|---|---|---|---|---|---|
| | | | Min. | Max. | Min. | Max. | | |
| 1 | Existing Building | - | - | - | - | - | - | 16.31 |
| 2 | Install Flue Dampers | 3.4 | 31 | 62 | 6 | 6 | 2.7 | 15.88 |
| 3 | Block and Insulate Windows | 41.7 | 127 | 279 | 12 | 13 | 13.0 | 14.19 |
| 4 | Insulate Roof | 25.3 | 32 | 83 | 18 | 22 | 4.4 | 15.60 |
| 5 | Reduce Vent & Exhaust: Floors 3-8 | 4.3 | 416 | 849 | 1 | 1 | 29.9 | 11.43 |
| 6 | Reduce Vent & Exhaust: Floors 1-2 | 1.7 | 26 | 53 | 4 | 4 | 2.0 | 15.98 |

3. LIFE CYCLE CONSERVATION RECOMMENDATIONS

a. The following recommendations, in order of priority, are to conserve energy and reduce the Life Cycle owning and operating costs of Petro Hall.

1. Alternative #5

Reduce ventilation and exhaust rates for the dormitory areas; floors three through eight. Estimated energy savings are 29.9% with a payback of one year for an investment of $4,282.00.

2. Alternative #6

Reduce ventilation and exhaust rates for the first and second floors. Estimated energy savings are 2.0% with a payback of four years for an investment of $1,701.00.

3. Alternative #2

Install boiler flue dampers. Estimated energy savings are 2.7% with a payback of six years for an investment of $3,435.00.

4. Alternative #3

Block and insulate 60% of the glass area. Estimated energy savings are 13.0% with a payback of 12 to 13 years for an investment of $41,663.00.

5. Alternative #4

Add four inches of beadboard to existing roof insulation when reroofing. Estimated energy savings are 4.4% with a payback of 18 to 22 years for an investment of $25,288.00.

## E. MSU FIELD HOUSE

### 1. BUILDING DESCRIPTION

#### a. General

The MSU Field House was built in 1956 as the Health & Physical Education Center for Montana State College. Two additions have been made to the original building. Both increased the office area in the northwest office wing. The total added area is approximately 2400 square feet. The building is basically composed of 3 distinct sections: arena, lobby, and northwest office wing.

The arena is a 155 foot radius cylinder extending 34 feet above the existing grade with a five foot glass extension. The arena roof is a partial hemisphere resting on the top of the arena cylindrical walls. The maximum height from the roof to the floor is 91 feet. The arena area also includes locker rooms, hallways, and stadium seats on the north and south sides. A mezzanine is above the locker rooms and hallways on both sides. The mezzanine, locker rooms, and hallways fill the void created by the elevated stadium seats. The arena floor is compacted dirt at this time.

The lobby extends a little less than one-fourth the way around the arena cylinder on the west side. The lobby roof is convex shaped when viewed looking east. The maximum roof height is approximately 18 feet. The western face is slightly concave with respect to the interior. The south end of the lobby includes a small mechanical room, storage area, and toilet. The northwest office wing extends from the northern side of the lobby. Approximately one-fourth of the office floor area is suspended above an open walkway. Another one-fourth of the area is built under what was an exposed floor area of the original office area. The remaining one-half of the office area is built on grade.

1. BUILDING DESCRIPTION (CONTINUED)

b. Building Envelope

Arena and lobby walls are uninsulated 8 inch concrete block. The office area is 8 inch concrete block with 4 inch face brick.

The arena, lobby and office roofs are wood planking with 2 inches of acoustical and low grade thermal insulation. The glass areas of the arena and lobby are double glazed with the glass area in the office area being single glazed. The only operable window vents are in the office area. The vents lack weatherstripping and are moderate to poor fitting. Caulking around the frames appears good, but window design prevents further improvement.

c. Heating and Ventilation

The arena area is supplied with fresh air and heating from 18 heating and ventilating units attached to the arena roof. Seven exhaust units located at the top of the arena roof provide relief air. Air is exhausted from the locker rooms and toilets located under the stadium seating which enters these areas from the arena via unit heaters. Heat is supplied by steam produced at the central physical plant.

The lobby heating and ventilating system consists of one unit that supplies tempered air for the area inside the glass doors and facade. Air relief is provided by the arena/locker room exhaust system. Heating is supplied by steam produced at the central physical plant.

All above mentioned heating and ventilating units and exhaust systems are manually controlled for off-on operation, except the lobby H and V unit, which is on a timeclock. Temperature control is minimal for the arena units.

1. BUILDING DESCRIPTION (CONTINUED)

The office heating and ventilating system consists of mostly fin tube with 2 unit ventilation. The most recent addition is heated with electrical resistance heating, while the remaining area uses the centrally supplied steam.

Domestic hot water is supplied by a steam to water heat exchanger with two 3700 gallon storage tanks for reserve.

At this time, no portion of the MSU Field House is cooled.

2. LIFE CYCLE ENERGY ANALYSIS

a. Description of Alternatives

The following alternatives were investigated for achieving energy conservation.

Alternative #1

This alternative is the existing building "as is". Alternative #1 is used as the basis for comparison against subsequent alternatives. A maintenance cost for changing burned out lamps is included in this alternative and all other alternatives, except Alternvative #6. Since Alternative #6 requires a lower maintenance cost than the other alternatives, the difference in annual costs is added to all other alternatives.

Alternative #2

Install a hydronic heat recovery system on two exhaust fans and four heating and ventilating units in the arena area. This alternative involves installing an air to water/glycol solution heat exchanger in

2. LIFE CYCLE ENERGY ANALYSIS (CONTINUED)

the air exhaust stream of two of the exhaust units at the top of the arena dome. The heated solution is then pumped to a water/glycol to air heat exchanger. Each exhaust unit will supply heat to two heating and ventilating units which will dissipate the collected heat into a stream of fresh air that is required for make up air.

Alternative #3

During unoccuppied times, recirculate air that is currently exhausted continuously from the locker, toilet, and storage rooms. This reduces the amount of fresh air (which has to be heated) needed to make up air. A time clock will provide for automatic unoccuppied-occuppied cycling. During special events, the time clock can be overridden.

Alternative #4

Install a separate heating and ventilating unit to supply fresh air to the office area. Currently, the lobby heating and ventilating unit is turned on to supply fresh air to the office area. This unit is over-sized and improperly used for this purpose. However, with a separate H & V unit installed in the ceiling of the lobby and air ducted to the office corridor, a sufficient volume of fresh air is supplied to the offices. Energy savings result due to reduced volumes of fresh air to heat and reduced electrical consumption due to a smaller fan motor.

Alternative #5

Install a night setback system. This alternative provides needed temperature control for times when the building is shut down overnight or for extended periods. The night setback is controlled

2. LIFE CYCLE ENERGY ANALYSIS (CONTINUED)

differently for the arena and locker rooms than for the office and lobby areas. In this manner, the office can be used daily while the arena is at a minimum temperature.

Alternative #6

Install energy efficient lamps in the arena and lobby areas. The arena lamps currently consist of 1500 watt incandescent lamps over the non-seating area and 1000 watt lamps over the seating areas. A 1000 watt metal halide lamp is used to replace every other 1500 watt incandescent lamp. The remaining 1500 watt incandescent lamps are removed. Under this configuration, the illumination increases by 17%. The 1000 watt lamps over the seating area are replaced on a one for one basis with a 400 watt metal halide lamp. This increases the illumination by 6.5%.

The 300 watt incandescent lobby lamps are replaced with 75 watt high pressure sodium lamps on a one for one basis. The illumination decreases by 10%.

In addition to the reduction in energy use, the new lamps are rated with longer lifetimes than the incandescent lamps. This results in a net annual maintenance savings based on lamp costs, lamp life, and replacement time. See Alternative #1 for incorporation of this economic factor. (NOTE: The introduction of high intensity discharge lamps does not allow for instant on operations. However, if this is a desired quality, the removed 1500 watt incandescent lamps could be retained to provide instantaneous lighting until the high intensity lamps are fully operational.)

2. LIFE CYCLE ENERGY ANALYSIS (CONTINUED)

Alternative #7

Valve off one domestic hot water storage tank and insulate the remaining storage tank with an additional 2 inches of fiberglass blanket insulation. This reduces the stand by losses. With the current usage of the facility, one of the two 3700 gallon storage tanks supplies sufficient water.

Alternative #8

Install a semi-instantaneous domestic hot water heat exchanger. Both domestic hot water tanks are removed from the hot water circuit and hot water is directly supplied by the semi-instantaneous heat exchanger. Stand-by losses are further reduced over Alternative #7 to negligible amounts.

Alternative #9

Insulate the attic over the offices and lobby areas, including the storage and toilet areas on the south side of the lobby, with 15 inches of blown in insulation.

Alternative #10

Insulate the arena roof with 6 inches of beadboard. (NOTE: This alternative is to be done when the existing roof is replaced.)

Alternative #11

Insulate the exterior side of the arena, office and lobby exterior walls with 8 inches of beadboard covered with stucco. The travertine facing on the lobby is not covered with stucco.

Alternative #12

Enclose the exposed office floor area with metal paneling and fill

2. LIFE CYCLE ENERGY ANALYSIS (CONTINUED)

the resulting void with 15 inches of blown in insulation.

Alternative #13

Overlay the glass and Cemesto board 6.5 feet above the first floor up to the roof on the west face of the lobby with 2.5 inches of light transmitting insulation covered with a fiberglass panel. The resulting wall section is a thermopaned glass, 2.5 inches of insulation, and fiberglass panel. Remove the remaining existing thermopaned glass on the same level as the doors to the lobby and replace with two fiberglass panels sandwiching 3 inches of light transmitting insulation. Remove the windows and Cemesto board in the original office area and replace each window section with a 1 foot by 4 foot window. The remaining area is blocked to match the interior surface with concrete block, 8 inches of beadboard and an exterior covering of stucco finish.

b. Life Cycle Cost Summary

Table 7.4 is a summary of the Life Cycle Cost Analysis of each alternative showing the estimated first cost, the present worth of life cycle cost savings, the breakeven point or payback of first cost in years, the percent energy savings, and the energy consumption in Btu/gross square foot of building area/degree day of each alternative.

# MONTANA STATE UNIVERSITY

## FIELD HOUSE

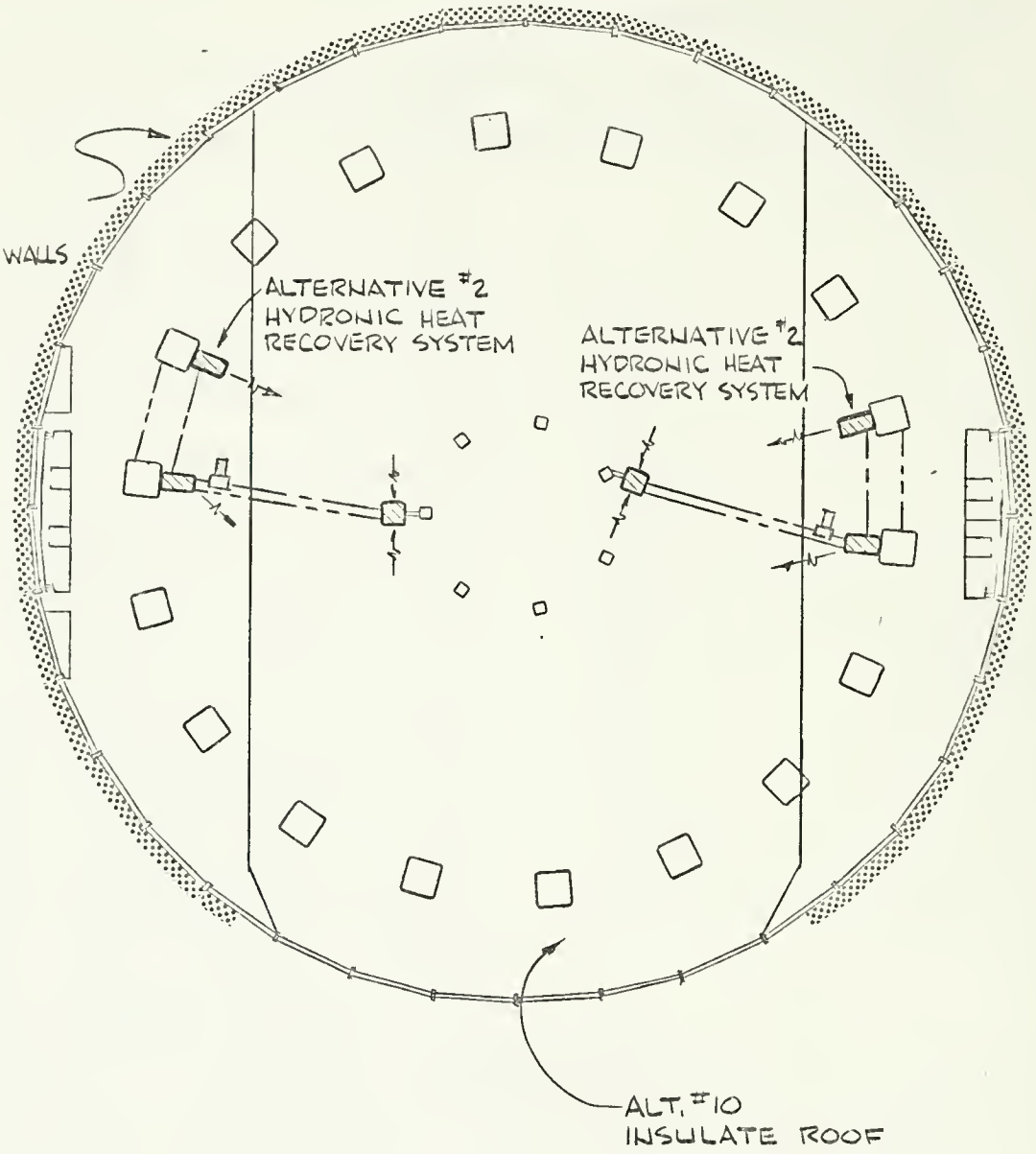
## LOBBY AREA

M.S.U. FIELD HOUSE
LOBBY AREA
BOZEMAN, MONTANA

DRAPES ENGINEERING
MECHANICAL & ELECTRICAL ENGINEERS
GREAT FALLS, MONTANA

DATE
SHEET
OF

7.31



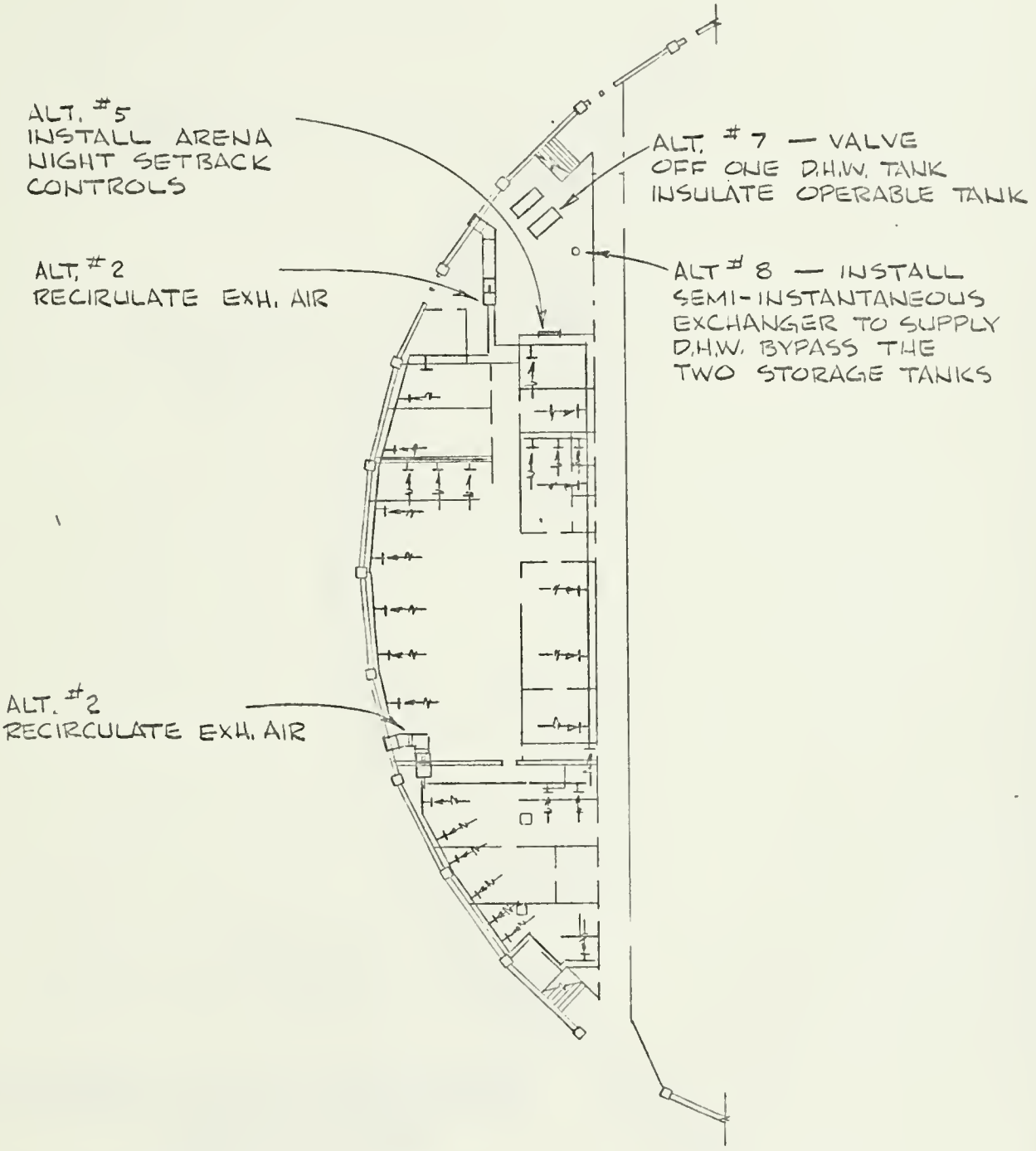

# MONTANA STATE UNIVERSITY

## FIELD HOUSE

## ARENA VENTILATION & WALLS

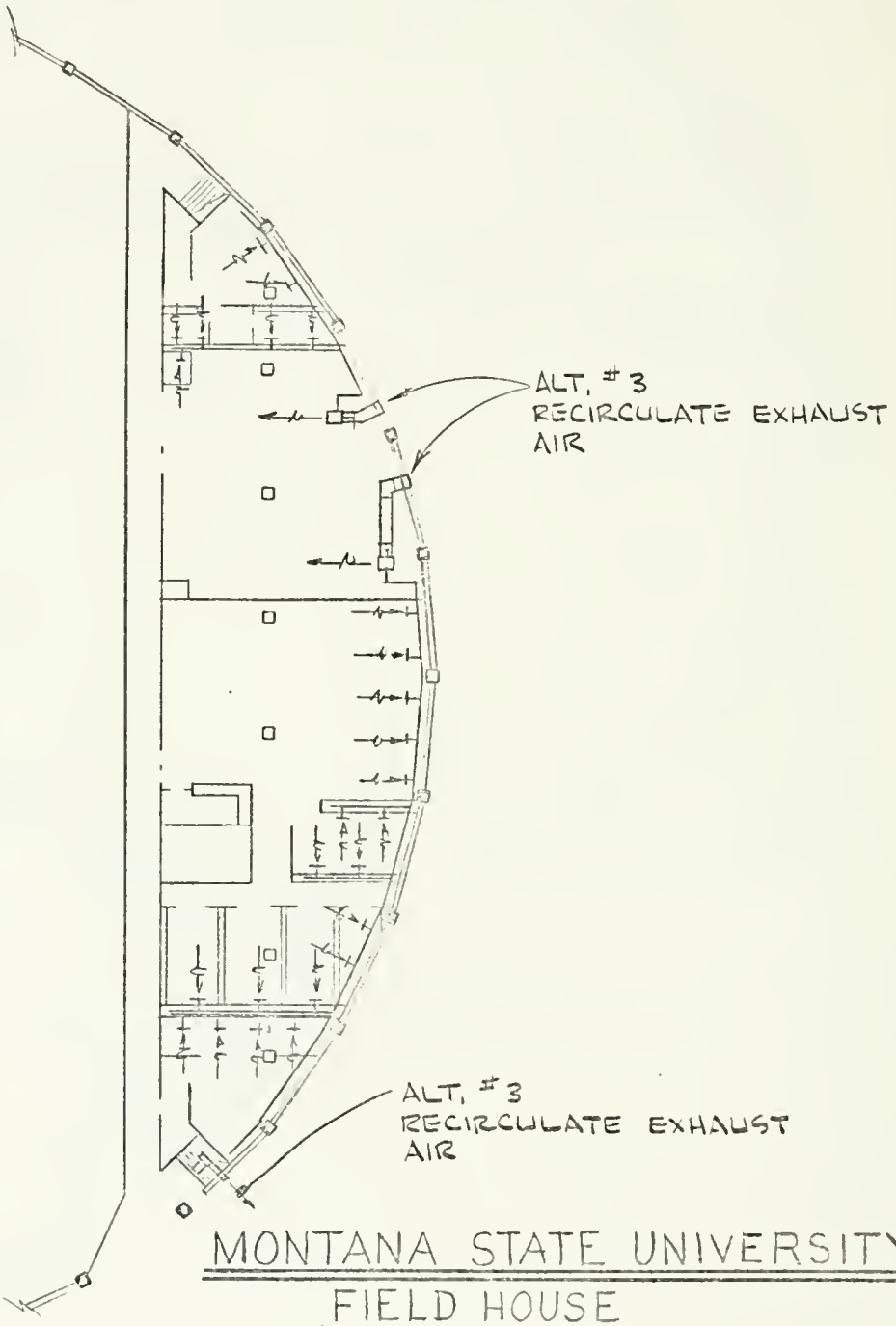
2

| | | |
|---|---|---|
| M.S.U. FIELD HOUSE<br>ARENA VENTILATION & WALLS<br>BOZEMAN, MONTANA | DRAPES ENGINEERING<br>MECHANICAL & ELECTRICAL ENGINEERS<br>GREAT FALLS, MONTANA | DATE 1/15/78<br>SHEET<br>OF |




# MONTANA STATE UNIVERSITY
## FIELD HOUSE
## GROUND FLOOR - NORTH

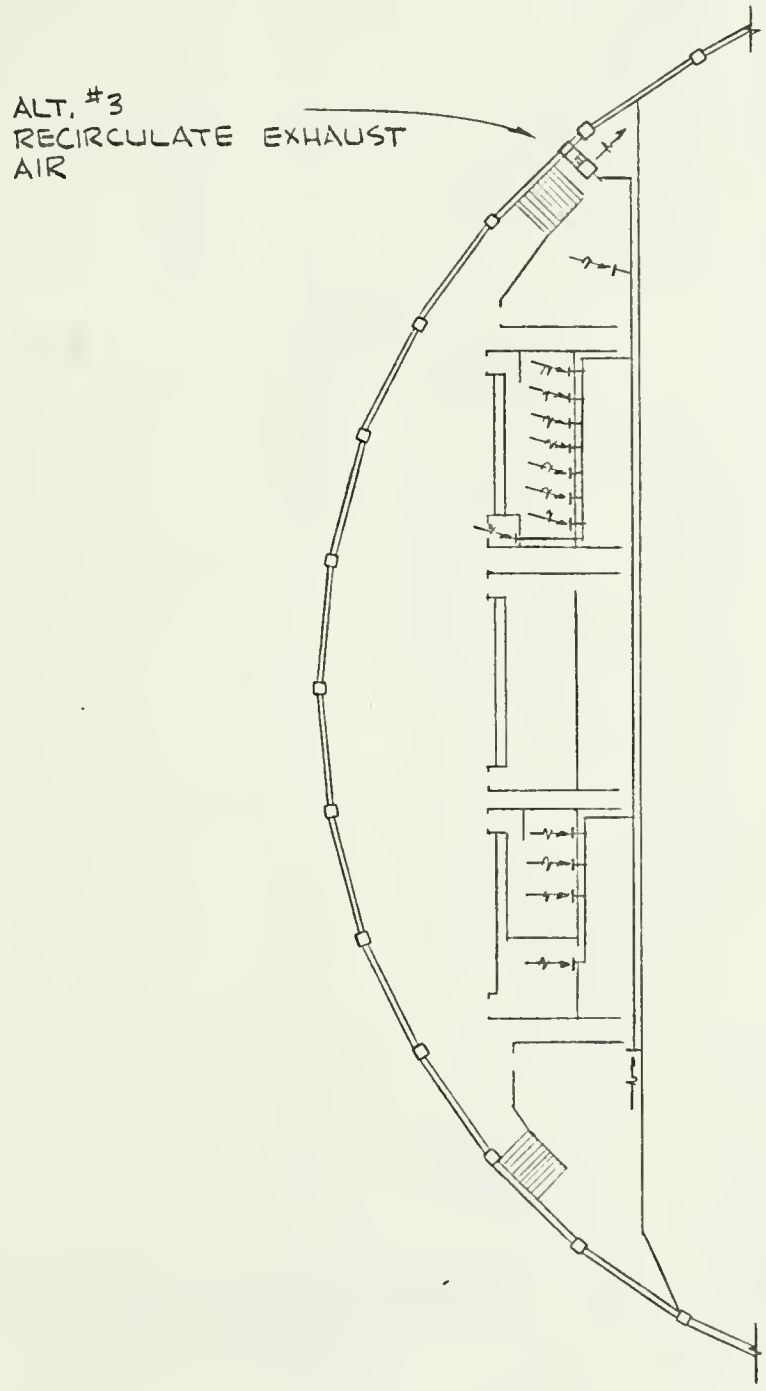
| | | |
|---|---|---|
| M.S.U FIELD HOUSE<br>GROUND FLOOR NORTH<br>BOZEMAN, MONTANA | DRAPES ENGINEERING<br>MECHANICAL & ELECTRICAL ENGINEERS<br>GREAT FALLS, MONTANA | DATE 1/3/73<br>SHEET<br>OF |




# MONTANA STATE UNIVERSITY
## FIELD HOUSE
## GROUND FLOOR - SOUTH

1

| | | |
|---|---|---|
| M.S.U. FIELD HOUSE<br>GROUND FLOOR SOUTH<br>BOZEMAN, MONTANA | DRAPES ENGINEERING<br>MECHANICAL & ELECTRICAL ENGINEERS<br>GREAT FALLS, MONTANA | DATE 11-7-78<br>SHEET<br>OF |




# MONTANA STATE UNIVERSITY
## FIELD HOUSE
## MEZZANINE FLOOR - NORTH

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| M.S.U. FIELD HOUSE<br>MEZZANINE FLOOR - NORTH<br>BOZEMAN, MONTANA | DRAPES ENGINEERING<br>MECHANICAL & ELECTRICAL ENGINEERS<br>GREAT FALLS, MONTANA |

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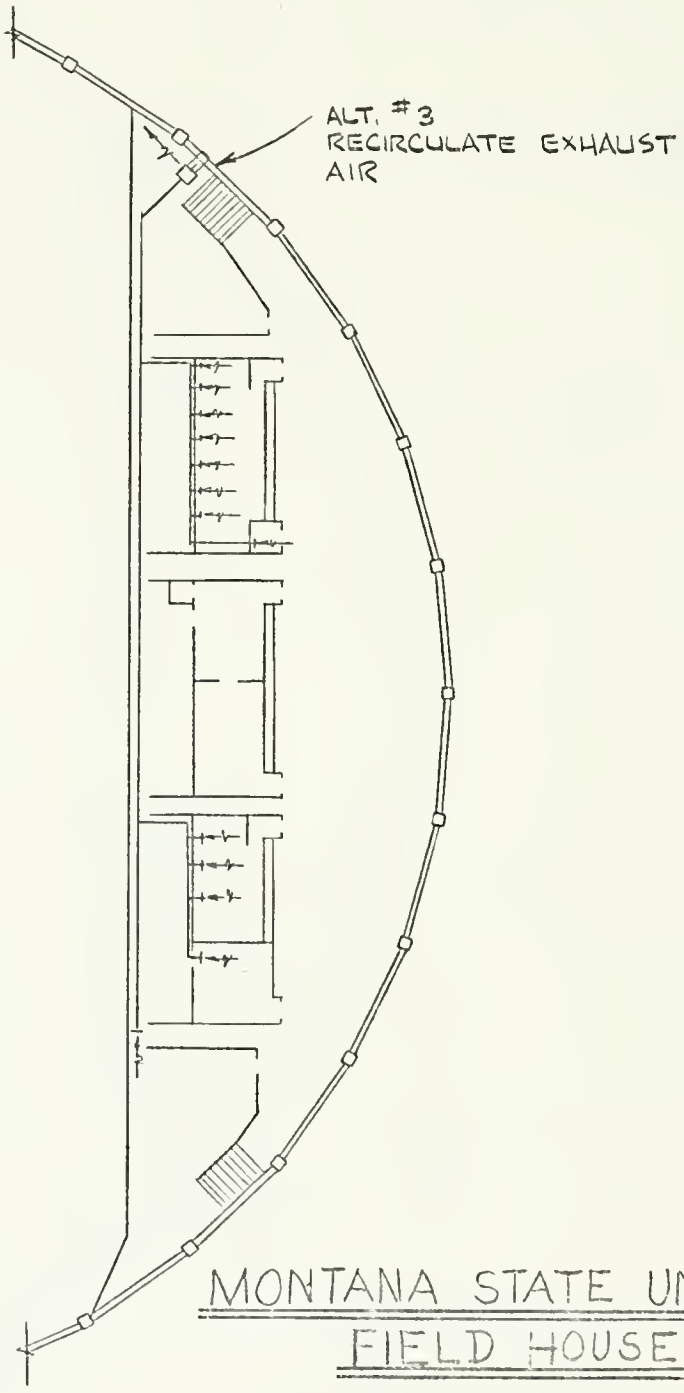



# MONTANA STATE UNIVERSITY
# FIELD HOUSE

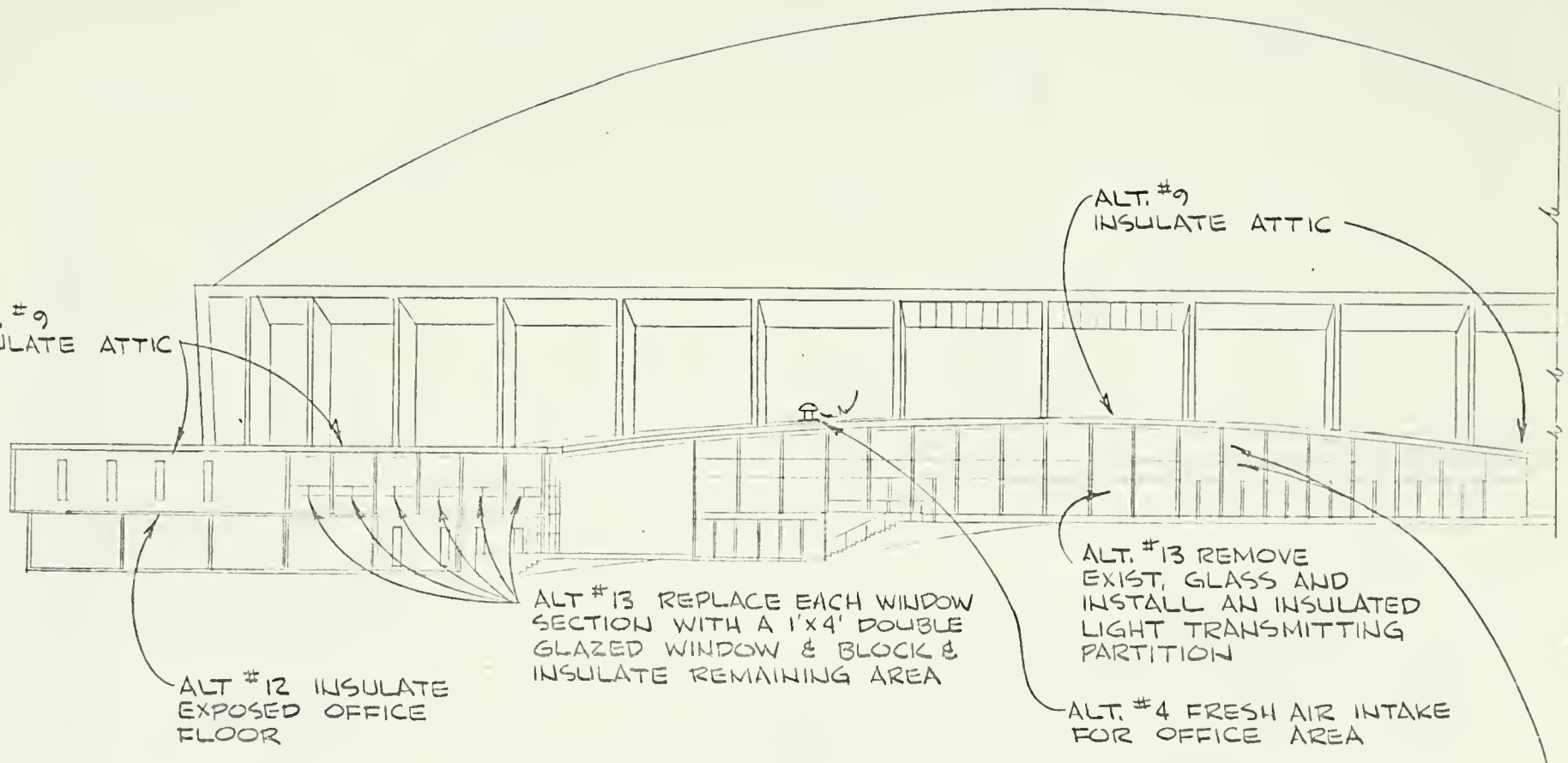
## MEZZANINE FLOOR - SOUTH

| | | |
|---|---|---|
| M.S.U. FIELD HOUSE<br>MEZZANINE FLOOR - SOUTH<br>BOZEMAN, MONTANA | DRAPES ENGINEERING<br>MECHANICAL & ELECTRICAL ENGINEERS<br>GREAT FALLS, MONTANA | DATE<br>SHEET<br>OF |

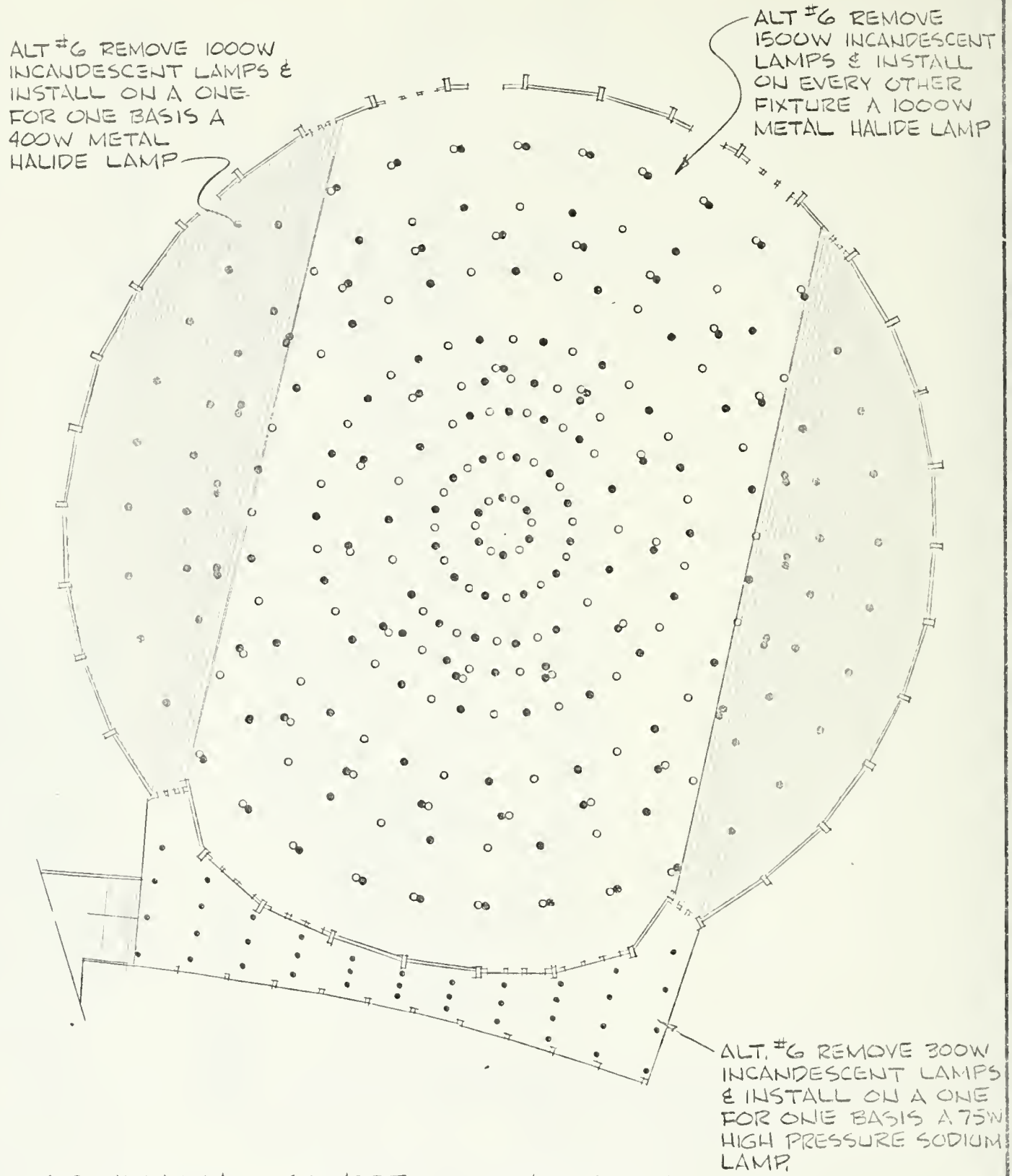
M.S.U. FIELD HOUSE
WEST ELEVATION
BOZEMAN, MONTANA

DRAPES ENGINEERING
MECHANICAL & ELECTRICAL ENGINEERS
GREAT FALLS, MONTANA

DATE 7/15/75
SHEET
OF


ALT. #9
INSULATE ATTIC
ALT. #9
INSULATE ATTIC
ALT #13 REPLACE EACH WINDOW SECTION WITH A 1'x4' DOUBLE GLAZED WINDOW & BLOCK & INSULATE REMAINING AREA
ALT #12 INSULATE EXPOSED OFFICE FLOOR
ALT. #13 REMOVE EXIST. GLASS AND INSTALL AN INSULATED LIGHT TRANSMITTING PARTITION
ALT. #4 FRESH AIR INTAKE FOR OFFICE AREA
ALT. #13 LAY OVER EXIST. GLASS & CEMESTO BOARD INSULATION & A LIGHT TRANSMITTING PANEL

# MONTANA STATE UNIVERSITY
## FIELD HOUSE
## WEST ELEVATION (PARTIAL)


ALT #6 REMOVE 1000W INCANDESCENT LAMPS & INSTALL ON A ONE-FOR ONE BASIS A 400W METAL HALIDE LAMP
ALT #6 REMOVE 1500W INCANDESCENT LAMPS & INSTALL ON EVERY OTHER FIXTURE A 1000W METAL HALIDE LAMP
ALT. #6 REMOVE 300W INCANDESCENT LAMPS & INSTALL ON A ONE FOR ONE BASIS A 75W HIGH PRESSURE SODIUM LAMP.

# MONTANA STATE UNIVERSITY

## FIELD HOUSE

## ARENA & LOBBY LIGHTING PLAN

| | | |
|---|---|---|
| M.S.U. FIELD HOUSE<br>ARENA & LOBBY LIGHTING<br>BOZEMAN MONTANA | DRAPES ENGINEERING<br>MECHANICAL & ELECTRICAL ENGINEERS<br>GREAT FALLS, MONTANA | DATE 1/17/75<br>SHEET<br>OF |

TABLE 7.4

LIFE CYCLE COST SUMMARY

MSU FIELD HOUSE

| Alt. | Alternative Description | First Cost ($1000's) | Present Worth of Life Cycle Cost Savings ($1000's) | | Breakeven On First Cost (Yr) | | Percent Energy Savings | EUI BTU/GSF-DD |
|---|---|---|---|---|---|---|---|---|
| | | | Min. | Max. | Min. | Max. | | |
| 1 | Existing Building | - | - | - | - | - | - | 16.92 |
| 2 | Hydronic Heat Recovery System | 47 | 163 | 338 | 11 | 12 | 7.2 | 15.70 |
| 3 | Recirculate Exhaust Air | 3.4 | 403 | 750 | 1 | 1 | 13.9 | 14.57 |
| 4 | Install Separate Fresh Air Supply for Offices | 4.5 | 9 | 30 | 12 | 14 | 0.7 | 16.81 |
| 5 | Install Night Setback System | 28 | 68 | 149 | 13 | 15 | 3.3 | 16.37 |
| 6 | Relamp Arena & Lobby With Energy Efficient Lamps | 36 | 223 | 578 | 5 | 6 | 3.9 | 16.26 |
| 7 | Use only One DHW Tank w/Additional Insulation | .8 | 8.2 | 16 | 5 | 5 | 0.3 | 16.87 |
| 8 | Replace DHW Tanks w/Semi-Instantaneous System | 5.7 | 6.2 | 16 | 19 | 23 | 0.4 | 16.85 |
| 9 | Insulate Attic Area Over Office, Storage & Lobby | 16 | 40 | 87 | 13 | 15 | 1.9 | 16.60 |
| 10 | Insulate Arena Roof | 122 | 19 | 139 | 27 | 36 | 4.8 | 16.10 |
| 11 | Insulate Exterior Side of the Exterior Walls | 127 | 168 | 418 | 17 | 21 | 10.0 | 15.22 |
| 12 | Insulate Exposed Office Floor | 4.0 | .35 | 4.1 | 28 | 38 | 0.1 | 16.89 |
| 13 | Install Light Transmitting Partition & Block Windows | 13 | 11 | 32 | 20 | 25 | 0.8 | 16.78 |

3. LIFE CYCLE CONSERVATION RECOMMENDATIONS

a. The following recommendations, in order of priority, are to conserve energy and reduce the Life Cycle owning and operating costs of the MSU Field House.

1. Alternative #3

During unoccuppied times, recirculate air that is currently exhausted continuously from the locker, toilet, and storage rooms. This provides an estimated energy savings of 13.9% for an investment of $3400, with a payback of 1 year.

2. Alternative #7

Valve off one domestic hot water storage tank and insulate the remaining storage tank with an additional 2 inches of fiberglass blanket insulation. This provides an estimated energy savings of 0.3% for an investment of $810 with a payback of 5 years.

3. Alternative #6

Install energy efficient lamps in the arena and lobby areas. This provides an estimated energy savings of 3.9% for an investment of $35,600 with a payback of 5 to 6 years (minimum to maximum)

4. Alternative #2

Install a hydronic heat recovery system on two exhaust fans and four heating and ventilating units in the arena area. This provides an estimated energy savings of 7.2% for an investment of $47,000, with a payback of 11 to 12 years.

5. Alternative #5

Install a night setback system. This provides an estimated energy savings of 3.3% for an investment of $28,100 with a payback of 13 to 15 years.

3. LIFE CYCLE CONSERVATION RECOMMENDATIONS (CONTINUED)

6. Alternative #4

Install a separate heating and ventilating unit to supply fresh air to the office area. This provides an estimated energy savings of 0.7% for an investment of $4500 with a payback of 12 to 14 years.

7. Alternative #9

Insulate the attic over the offices and lobby areas (including the storage and toilet areas on the south side of the lobby) with 15 inches of blown in insulation. This provides an estimated energy savings of 1.9% for an investment of $15,600 with a payback of 13 to 15 years.

8. Alternative #11

Insulate the exterior side of the arena, offices and lobby exterior walls with 8 inches of beadboard covered with stucco. This provides an estimated energy savings of 10.0% for an investment of $126,700 with a payback of 17 to 21 years.

9. Alternative #13

Overlay the glass and Cemesto board 6.5 feet above the first floor on up to the roof on the west face of the lobby with 2.5 inches of light transmitting insulation covered with a fiberglass panel. Remove the remaining thermopaned glass on the same level as the doors to the lobby and replace with two fiberglass panels, sandwiching 3 inches of light transmitting insulation. Remove the window and Cemesto board in the original office area and replace each window section with a 1 foot by 4 foot window. The remaining area is blocked to match the interior surface with concrete block, 8 inches of beadboard and an exterior covering of stucco finish. This provides

3. LIFE CYCLE CONSERVATION RECOMMENDATIONS (CONTINUED)

an estimated energy savings of 0.8% for an investment of $13,200 with a payback of 20 to 25 years.

10. Alternative #10

Insulate the arena roof with 6 inches of beadboard. This provides an estimated energy savings of 4.8% for an investment of $122,100 with a payback of 27 to 36 years.

11. Alternative #12

Enclose the exposed office floor area with metal paneling and fill the resulting void with 15 inches of blown in insulation. This provides an estimated energy savings of 0.1% for an investment of $4000 with a payback of 28 to 38 years.

1. BUILDING DESCRIPTION

a. General

The eastern third of the MSU Library building is the original library built in 1949. In 1960, an addition was added that quadrupled the size of the library.

The original library consists of 3 above grade floors and one below grade floor. The topmost floor is an attic area with a sloped roof, reducing the usable floor space. The first floor and part of the basement consist of office space that is predominately occupied during the daytime. The remaining sections of the basement and the second and third floors are for storage and mechanical areas.

The 1960 addition consists of 4 above grade floors and one below grade floor. The fourth floor is approximately one-half the size of the third floor, with all other floors being equal. The addition was intentionally oversized with the upper floors originally not used. However, full occupancy started in late 1976. In the basement, a fountain and garden area, forming a courtyard, are installed. Each floor is open above the indoor courtyard with a rooftop skylight providing daytime illumination. The remaining areas of each floor consist of book shelves, study areas and mechanical rooms.

b. Building Envelope

The original building's walls are uninsulated 11 inch concrete with a 4 inch face brick. The sloped roof consists of wood rafters, pine decking, and asbestos shingles. The flat portion of the original building's roof is similar, except a built up roof is used instead of shingles, and one inch blanket insulation is installed above the sheet-rock ceiling. The windows are single glazed, lack weatherstripping

1. BUILDING DESCRIPTION (CONT'D)

around the sash, and are poor fitting. Although the window frames were caulked and appeared well insulated, further weatherstripping appears to be impractical due to window design.

The 1960 addition's walls are uninsulated 12 inch concrete blocks with 4 inch face brick, except for the fourth floor. The fourth floor walls are constructed with 8 inch concrete blocks and a one inch asbestos board; however, since the asbestos board is set out 1 to 2 inches from the wall and is ventilated, no insulating value is obtained from this portion of the wall. The roof over the third and fourth floors is constructed with a built-up roof and 2 inch fesco board on a concrete deck. Windows in the addition are thermal insulating with good seals.

c. Heating, Ventilation and Air-Conditioning System

No cooling is accomplished at this time in the original building. Heating is accomplished with steam in perimeter fin tube and in a heating and ventilating unit. Fresh air is introduced into the building thru this H and V unit and is exhausted thru a rooftop exhaust unit.

The 1960 addition had air-conditioning installed in the early 1970's. The cooling is provided by a steam absorption chiller supplying chilled water to cooling coils located in the 5 multizone units (one on each floor). There is no perimeter heating with all heating supplied with steam heating coils in each multizone unit.

When the 1960 addition was built, a snowmelting system was installed for each new entryway. The snowmelting system uses steam to heat a water-glycol solution that is circulated in pipes laid in the concrete slabs.

2. LIFE CYCLE ENERGY ANALYSIS

a. Description of Alternatives

The following alternatives were investigated for achieving energy conservation.

Alternative #1

This alternative is the existing building "as is". Alternative #1 will be used as the basis for comparison against subsequent alternatives.

Alternative #2

Replace the steam driven absorption chiller with an electrically driven centrifugal chiller in the 1960 addition. The basis for this alternative is that an electrically driven centrifugal chiller operates approximately 5 times more efficiently than the absorption chiller.

Alternative #3

Instrument the snow melting system. Under current operations, the snow melting system is turned on manually in October and is left on continuously until manually turned off in April or May. This alternative proposes to install sensors that would detect snow on the walks and then mechanically start and stop the snowmelting system.

Alternative #4

Install cold deck reset temperature control on multizone units in 1960 addition. A cold deck reset temperature control resets the mixed air temperature dependent upon the required minimum cooling

2. LIFE CYCLE ENERGY ANALYSIS (CONT'D)

temperature required to cool the zone requiring the most cooling. This reduces the amount of heat that is required to heat the mixed air up to room temperature for all other zones.

Alternative #5

Revise the multizone units in the 1960 addition into a variable air volume system.

Alternative #6

Reduce minimum fresh air from 20% to 10% in the 1960 addition and reduce the exhaust rate in the original building. Currently, the intake dampers are set for a minimum of 20% fresh air of the total circulated air in the 1960 addition, while the standard practice is the use of only 10% fresh air. The original building's exhaust is reduced by 55%.

Alternative #7

Install separate night setback controls in the original building, Present operation requires that the office area be maintained at daytime temperatures until the library closes. Installing separate night setback controls allows the original building to start the night's setback operation earlier than under current operations.

Alternative #8

Insulate the interior surfaces of the exterior walls in the original building and the 1960 addition with 3.5 inch troweled-on foam, covered with 5/8 inch sheetrock, mounted on metal studs.

2. LIFE CYCLE ENERGY ANALYSIS (CONT'D)

Alternative #9

Insulate the roof areas in the following manner: insulate the interior side of the sloped roof of the original building with glued on 4 inch beadboard and cover with sheetrock; on the flat roof of the original building and all of the flat roof of the 1960 addition, insulate with 4 inch beadboard and 1-1/2 inch fesco board laid on top and then covered with built up roof. (Note: This alternative is to be done when the existing roof is replaced.)

Alternative #10

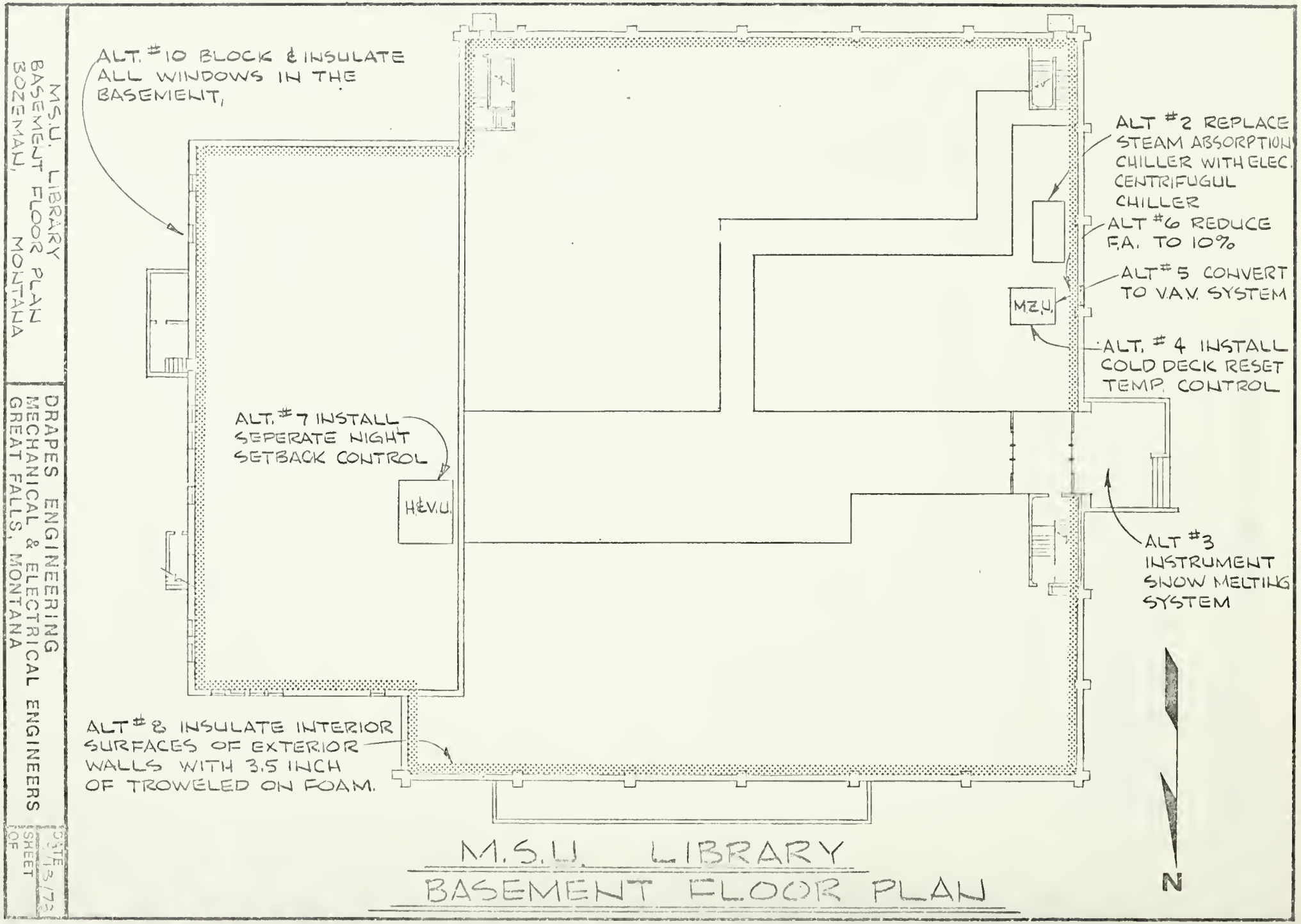
Block and insulate or install insulating windows in the original building. This alternative blocks and insulates all basement windows and 50% of the remaining windows are replaced with insulating windows. Since the current windows have a high leakage rate, replacement with tighter windows will necessitate some modification to the exhaust system to help maintain positive internal building pressure.

Alternative #11

Add a second, double-glazed skylight above the currently installed skylight. This will in effect provide quadruple glazing.

b. Life Cycle Cost Summary

Table 7.5is a summary of the Life Cycle Cost Analysis of each alternative showing the estimated first cost, the present worth of life cycle cost savings, the breakeven point or payback of first cost in years, the percent energy savings, and the energy consumption in Btu/gross square foot of building area/degree day of each alternative.


ALT. #10 BLOCK & INSULATE ALL WINDOWS IN THE BASEMENT,
ALT #2 REPLACE STEAM ABSORPTION CHILLER WITH ELEC. CENTRIFUGUL CHILLER
ALT #6 REDUCE F.A. TO 10%
ALT #5 CONVERT TO V.A.V. SYSTEM
M.Z.U.
ALT. #4 INSTALL COLD DECK RESET TEMP. CONTROL
ALT. #7 INSTALL SEPERATE NIGHT SETBACK CONTROL
H&V.U.
ALT #3 INSTRUMENT SNOW MELTING SYSTEM
ALT #8 INSULATE INTERIOR SURFACES OF EXTERIOR WALLS WITH 3.5 INCH OF TROWELED ON FOAM.
N
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BASEMENT FLOOR PLAN
M.S.U. LIBRARY
BASEMENT FLOOR PLAN
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DATE 5/13/72
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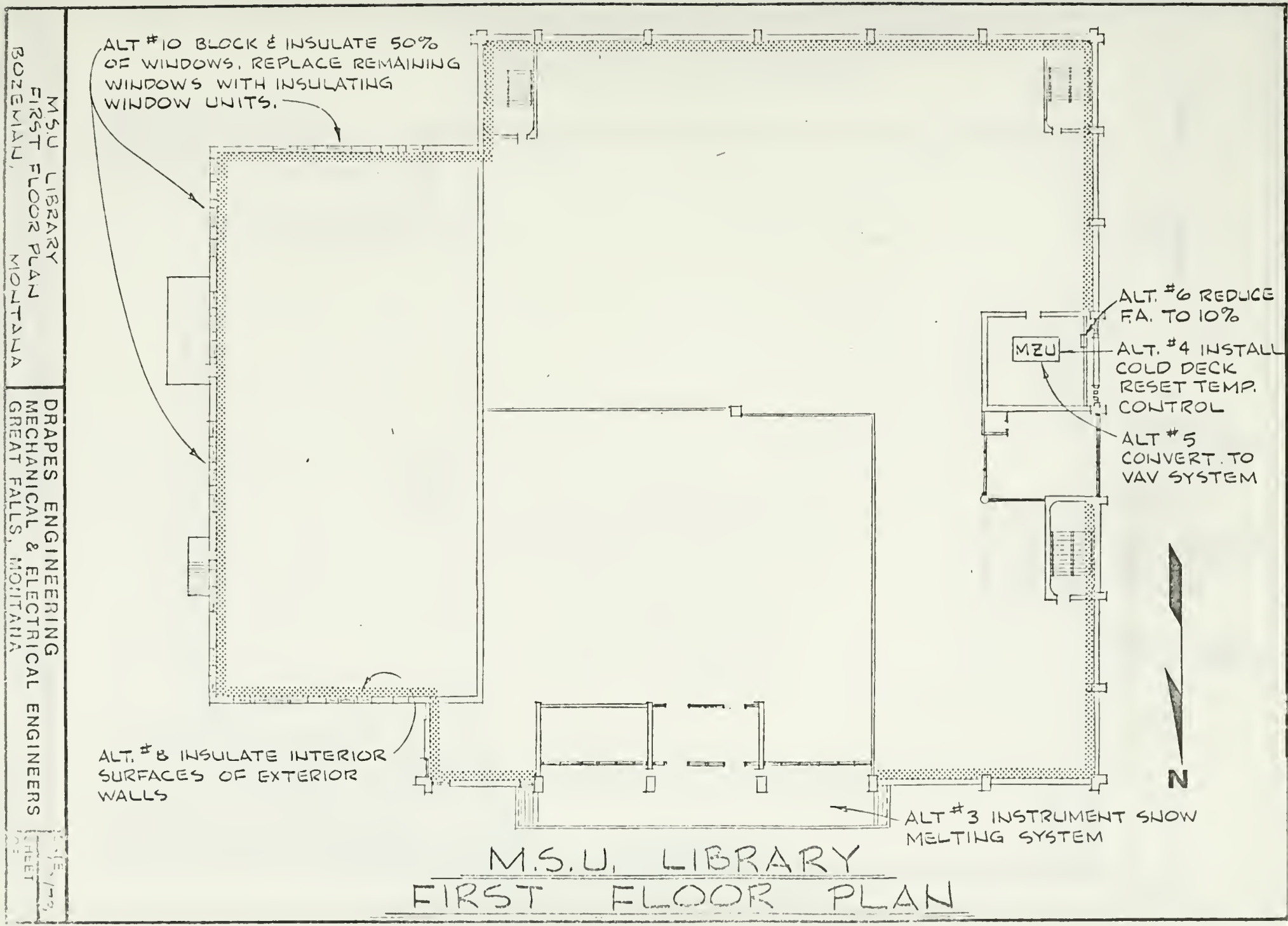
ALT #10 BLOCK & INSULATE 50% OF WINDOWS, REPLACE REMAINING WINDOWS WITH INSULATING WINDOW UNITS.
ALT. #6 REDUCE F.A. TO 10%
MZU
ALT. #4 INSTALL COLD DECK RESET TEMP. CONTROL
ALT #5 CONVERT TO VAV SYSTEM
N
ALT. #8 INSULATE INTERIOR SURFACES OF EXTERIOR WALLS
ALT #3 INSTRUMENT SNOW MELTING SYSTEM
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FIRST FLOOR PLAN

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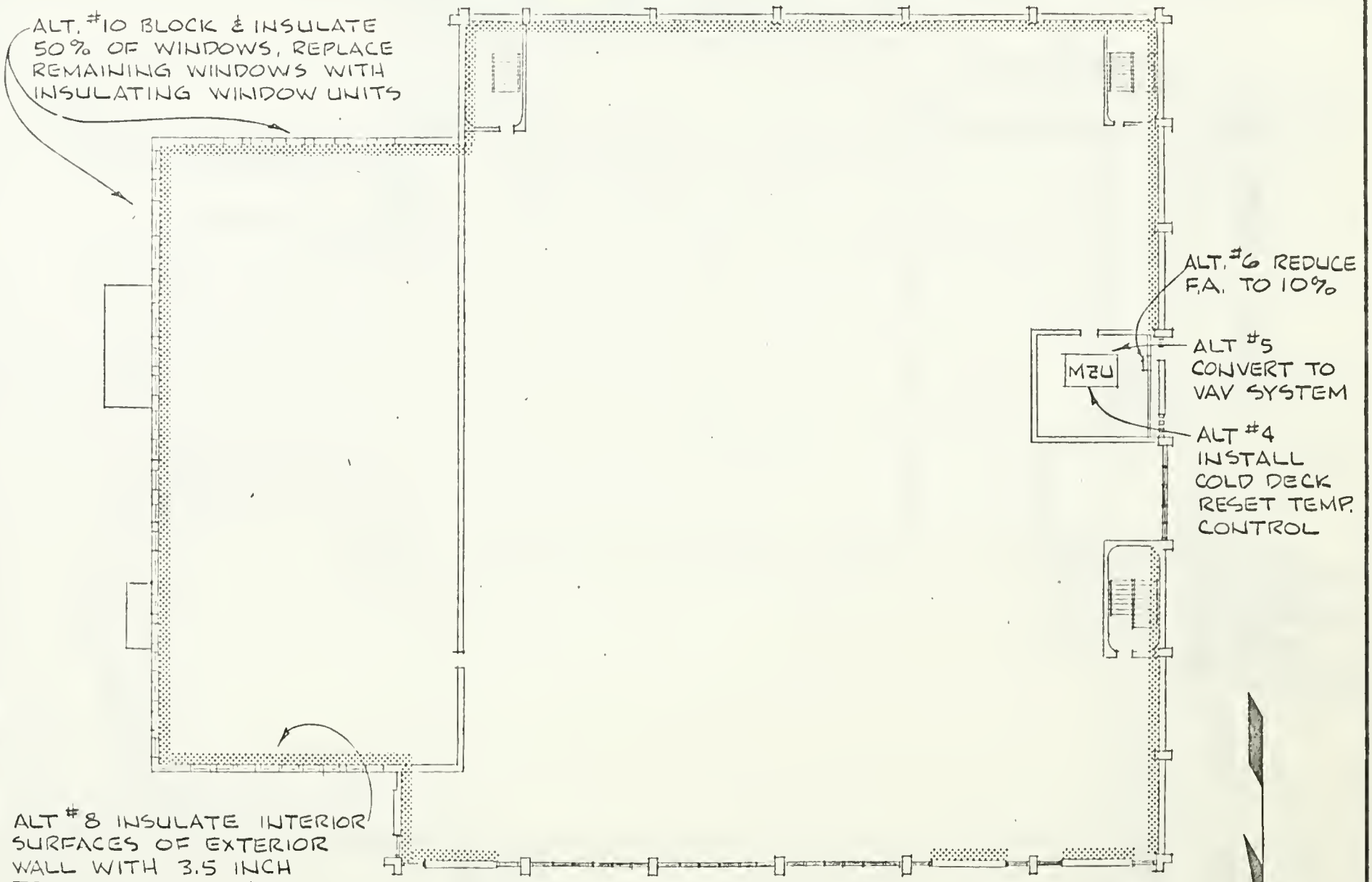
ALT. #10 BLOCK & INSULATE 50% OF WINDOWS, REPLACE REMAINING WINDOWS WITH INSULATING WINDOW UNITS
ALT. #6 REDUCE F.A. TO 10%
ALT #5 CONVERT TO VAV SYSTEM
MZU
ALT #4 INSTALL COLD DECK RESET TEMP. CONTROL
ALT #8 INSULATE INTERIOR SURFACES OF EXTERIOR WALL WITH 3.5 INCH TROWELED ON FOAM.
N

# M.S.U. LIBRARY
## SECOND FLOOR PLAN

M.S.U. LIBRARY
SECOND FLOOR PLAN
BOZEMAN, MONTANA

DRAPES ENGINEERING
MECHANICAL & ELECTRICAL ENGINEERS
GREAT FALLS, MONTANA

DATE 7-27-79
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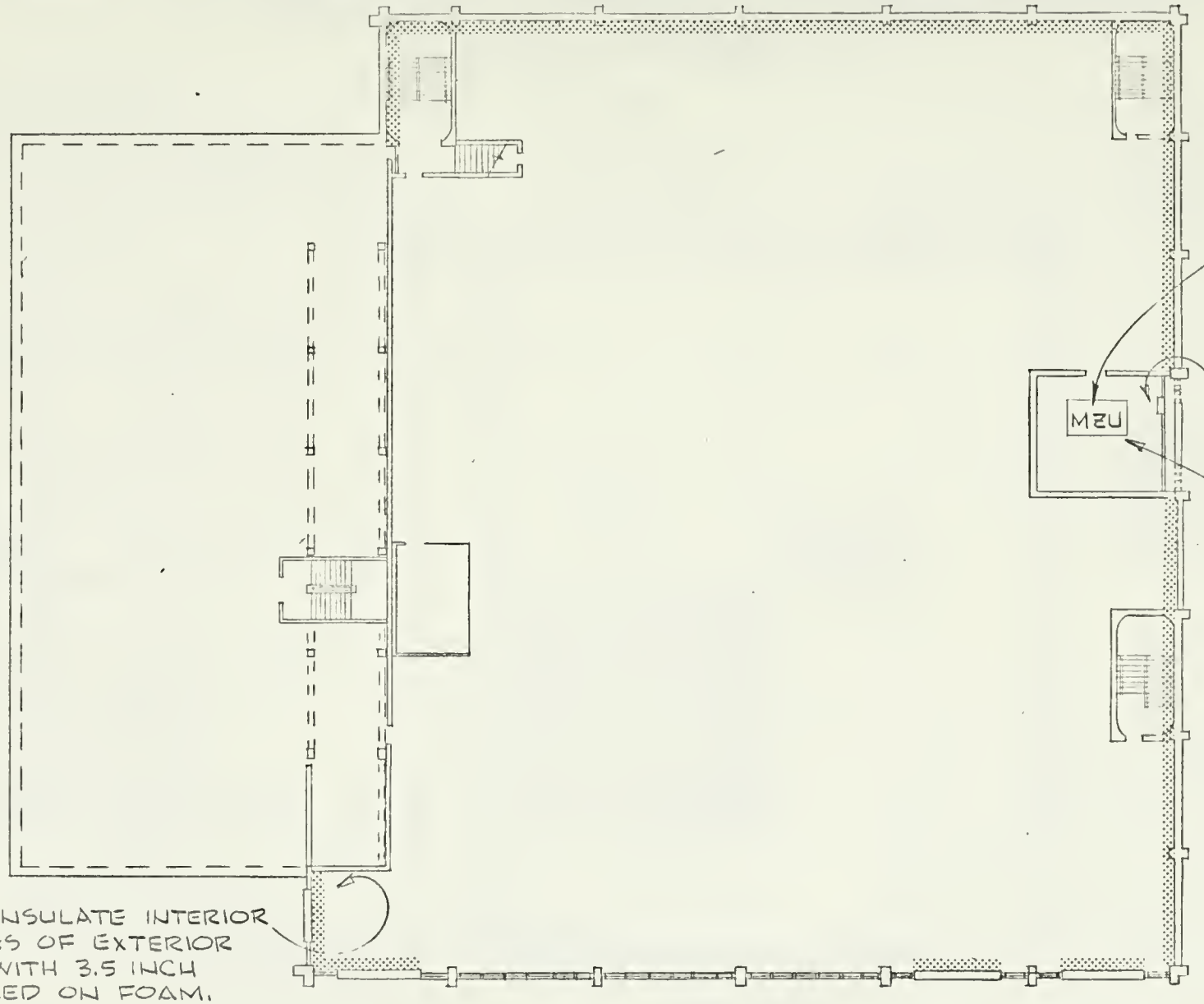
OF




# M.S.U. LIBRARY
# THIRD FLOOR PLAN

M.S.U. LIBRARY
THIRD FLOOR PLAN
BOZEMAN, MONTANA

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GREAT FALLS, MONTANA

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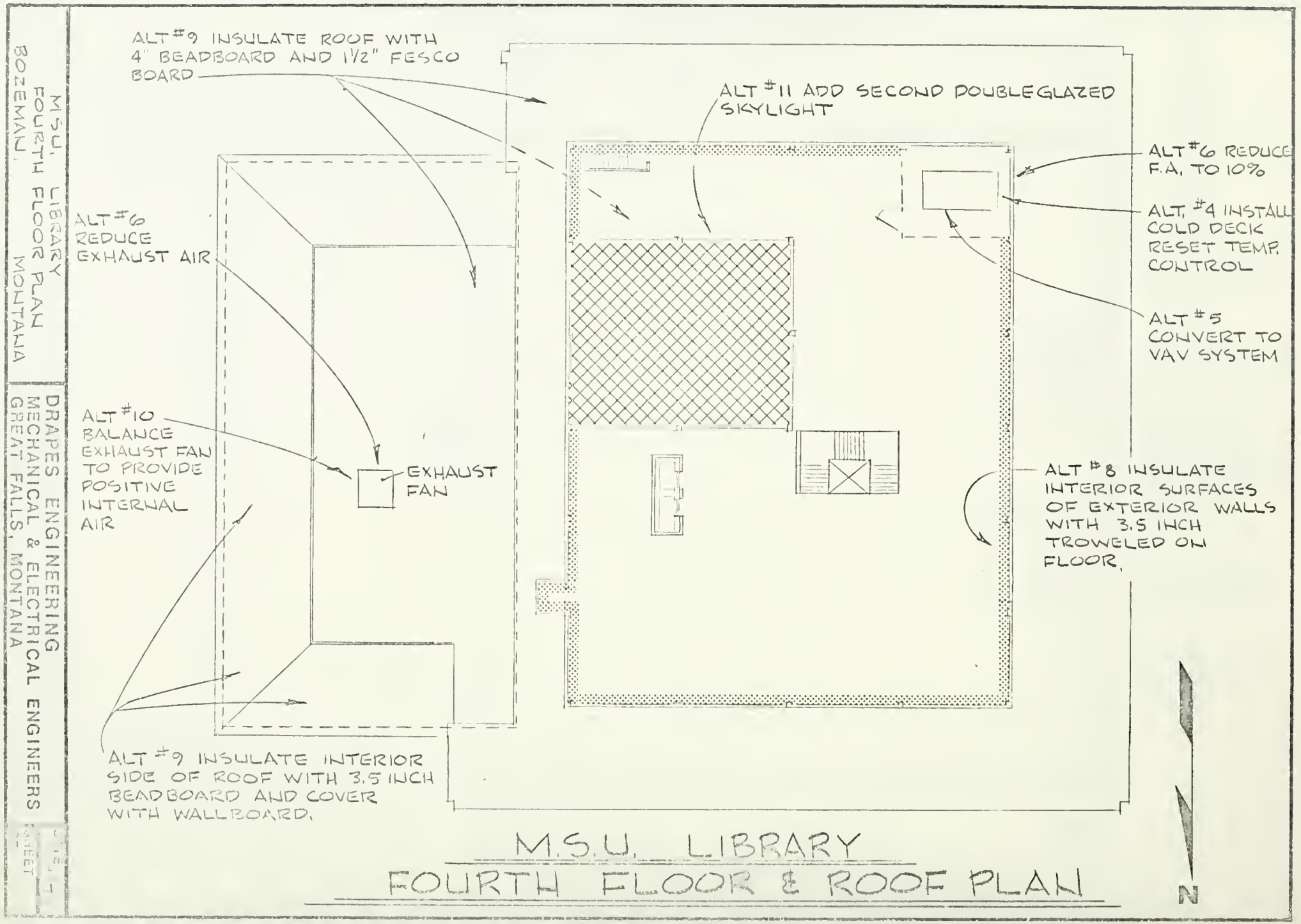
ALT #9 INSULATE ROOF WITH 4" BEADBOARD AND 1½" FESCO BOARD
ALT #11 ADD SECOND DOUBLEGLAZED SKYLIGHT
ALT #6 REDUCE F.A. TO 10%
ALT #4 INSTALL COLD DECK RESET TEMP. CONTROL
ALT #5 CONVERT TO VAV SYSTEM
ALT #6 REDUCE EXHAUST AIR
ALT #10 BALANCE EXHAUST FAN TO PROVIDE POSITIVE INTERNAL AIR
EXHAUST FAN
ALT #8 INSULATE INTERIOR SURFACES OF EXTERIOR WALLS WITH 3.5 INCH TROWELED ON FLOOR.
ALT #9 INSULATE INTERIOR SIDE OF ROOF WITH 3.5 INCH BEADBOARD AND COVER WITH WALLBOARD.
N

M.S.U. LIBRARY
FOURTH FLOOR & ROOF PLAN

M.S.U. LIBRARY
FOURTH FLOOR PLAN
BOZEMAN, MONTANA

DRAPES ENGINEERING
MECHANICAL & ELECTRICAL ENGINEERS
GREAT FALLS, MONTANA

DATE
SHEET

7.52

TABLE 7.5

LIFE CYCLE COST SUMMARY

MSU LIBRARY

| Alt. | Alternative Description | First Cost ($1000's) | Present Worth of Life Cycle Cost Savings ($1000's) Min. | Max. | Breakeven on First Cost (Yr) Min. | Max. | Percent Energy Savings | EUI BTU/GSF-DD |
|---|---|---|---|---|---|---|---|---|
| 1 | Existing Building | - | - | - | - | - | - | 20.57 |
| 2 | Replace Absorption Chiller w/Elec. Centrifugal Chiller | 64 | 314 | 536 | 10 | 10 | 7.5 | 19.02 |
| 3 | Instrument Snowmelt System | 1.1 | 127 | 237 | 1 | 1 | 2.5 | 20.06 |
| 4 | Cold Deck Reset | 1.1 | 26 | 49 | 3 | 3 | 0.5 | 20.46 |
| 5 | Variable Air Volume | 53 | 161 | 363 | 11 | 13 | 4.3 | 19.69 |
| 6 | Reduce FA Intake and Exhaust | .8 | 512 | 947 | 1 | 1 | 9.9 | 18.54 |
| 7 | Separate Night Setback for Original Building | .6 | 57 | 105 | 1 | 1 | 1.1 | 20.34 |
| 8 | Insulate Interior Side of Walls with Foam | .62 | 171 | 369 | 12 | 14 | 4.5 | 19.64 |
| 9 | Insulate Roof With Foam | 53 | 93 | 216 | 15 | 18 | 2.8 | 19.99 |
| 10 | Block and Insulate or Thermal Glaze Window Area | 29 | 23 | 67 | 21 | 26 | 1.0 | 20.36 |
| 11 | Add second Double Glazed Skylight to Existing Skylight | 40 | -26 | -15 | >40 | >40 | 0.3 | 20.52 |

3. LIFE CYCLE CONSERVATION RECOMMENDATIONS

a. The following recommendations, in order of priority, are to conserve energy and reduce the Life Cycle owning and operating costs of the MSU Library.

1. Alternative #6

Reduce minimum fresh air from 20% to 10% in this 1960 addition and reduce the exhaust rate in the original building. This provides an estimated energy savings of 9.9% for an investment of $780 with a payback of one year.

2. Alternative #3

Instrument the snow melting system. This provides an estimated energy savings of 2.5% for an investment of $1100 with a payback of one year.

3. Alternative #7

Install separate night setback controls in the original building. This provides an estimated energy savings of 1.1% for an investment of $550 with a payback of one year.

4. Alternative #4

Install cold deck reset temperature control on multizone units in 1960 addition. This provides an estimated energy savings of 0.5% for an investment of $1100 with a payback of 3 years.

5. Alternative #2

Replace the steam driven absorption chiller with an electrical driven centrifugal chiller in the 1960 addition. This provides an estimated energy savings of 7.5% for an investment of $64,000 with a payback of 10 years.

6. Alternative #5

Revise the multizone units in the 1960 addition into a variable air volume system. This provides an estimated energy savings of 4.3%

3. LIFE CYCLE CONSERVATION RECOMMENDATIONS (CONT'D)

for an investment of $53,000 with a payback of 11 to 13 years (minimum to maximum).

7. Alternative #8

Insulate interior surfaces of exterior walls in the original building and the 1960 addition with 3.5 inch troweled-on foam, covered with 5/8 inch sheetrock mounted on metal studs. This provides an estimated energy savings of 4.5% for an investment of $62,100 with a payback of 12 to 14 years.

8. Alternative #9

Insulate the roof areas in the following manner: insulate the interior side of the sloped roof of the original building with glued on 4 inch beadboard and cover with sheetrock; on the flat roof of the original building and all of the flat roof of the 1960 addition, insulate with 4 inch beadboard and 1-1/2 inch Fesco board laid on top and then covered with a built up roof. This provides an estimated energy savings of 2.8% for an investment of $52,700 with a payback of 15 to 18 years. (Note: This alternative is to be done when the existing roof is replaced.)

9. Alternative #10

Block and insulate or install insulating windows in the original building. This provides an estimated energy savings of 1.0% for an investment of $29,300 with a payback of 21 to 26 years.

1. BUILDING DESCRIPTION

a. General

The building was constructed in 1958. No additions or major exterior alterations have occurred since the building was first built.

The building foundation takes the form of an "L" with the wings being nearly equal in length. The ground floor of the south wing is comprised of four large lecture rooms. The eastern two lecture rooms' ceiling is the third floor slab. The western two lecture rooms' ceiling is a roof. There are two floors above the eastern lecture rooms with the space devoted to offices and conference rooms. The western wing is composed of four stories with space devoted to offices and conference rooms. The area common to the two wings form a lobby and two small lecture rooms on each floor.

A partial basement has been excavated under the west wing for the mechanical room and photography room. A small penthouse is on the roof housing mechanical and elevator equipment. The north entrance is composed of a four-story glass facade extending about nine feet out from the main wall.

b. Building Envelope

The walls are either composed of an exterior surface of four-inch face brick with a layer of four-inch common brick then an internal finish of four-inch face brick, or a second type of wall composed of an exterior surface of four-inch face brick with an internal finish of an eight-inch tile.

1. BUILDING DESCRIPTION (CONT'D)

The roof consists of a three-inch concrete slab with two-inch rigid insulation covered by a typical built-up roofing. The fourth floor ceiling is a suspended plaster ceiling with an undercovering of acoustical tile.

The windows are single-pane glass, lack weatherstripping, and are in moderate to poor sealing condition. Window frames are well caulked, but further weatherstripping appears to be impractical due to window design.

c. Heating and Ventilation

The south wing lecture rooms and the lecture rooms next to the lobbies, are heated with heating and ventilating units using steam heated coils. The remaining part of the building, the office and conference areas, are heated with a combination of perimeter hot water fin tube and a high velocity dual duct heating and ventilating unit with steam heating coils. Six cabinet heaters supply heated air to the lobbies.

Steam is supplied by a centralized heating plant on the campus.

At this time there is no mechanical air conditioning.

2. LIFE CYCLE ENERGY ANALYSIS

a. Description of Alternatives

The following alternatives were investigated for achieving energy conservation.

Alternative #1

This alternative is the existing building "as is". Alternative #1 will be used as the basis for comparison against subsequent alternatives.

Alternative #2

Revise heating and ventilating Unit #3 into VAV ventilating only unit. Heating and ventilating Unit #3 is the high velocity dual duct unit located in the penthouse supplying air to the offices and conference rooms.

Alternative #3

Revise heating and ventilating Units #1 and #2 into VAV ventilating only units. Heating and ventilating Units #1 and #2 supply heating and ventilating to the lecture rooms. Heating and ventilating Unit #1 is located between the upper portions of the south wing lecture rooms and heating and ventilating Unit #2 is located in the basement mechanical room.

Alternative #4

Install a thermostatic switch interlocked with an occupied/unoccupied switch to control the mechanical/photography rooms' exhaust fan. Currently the fan is left on continuously, exhausting both the mechanical and photography rooms. The alternative involves turning the exhaust fan on whenever the photography room is occupied and/or turning the exhaust fan on whenever the mechanical room needs ventilating (temperature dependent).

2. LIFE CYCLE ENERGY ANALYSIS (CONT'D)

Alternative #5

Install double-doored vestibules on all entrances. This alternative will reduce the amount of tempered air lost per door opening due to the air lock effect.

Alternative #6

Insulate the attic area above lecture room 105 and 108 and the attic area above the fourth floor with thirteen inches of blown-in insulation. Insulate the penthouse roof with six inches of beadboard when the penthouse roof is replaced. In rooms 105 and 108, insulate the nearly vertical ceiling portions, the second floor's wall common to the attic, and the third floor's floor common to the attic with ten inches of beadboard.

Alternative #7

Insulate the exterior walls on the exterior surface with six inches of glued-up beadboard covered with a finish of stucco.

Alternative #8

Block and insulate about 90% of the Sunlight 700 Series windows with a a matching interior and exterior finish and six inches of beadboard insulation. Install in the remaining 10% of unblocked area double-glazed vented glass. Block and insulate the east and west faces of Vestibule #1 with a matching interior and exterior finish and six inches of beadboard insulation. Install over the existing plate glass three inches of light transmitting insulation covered with a sheet of clear fiberglass. Install over the existing glass plate framing the entrance ways, two inches of light transmitting insulation covered with clear fiberglass. Replace the Tru-Seal Series 55 windows with double-glazed vented windows.

2. LIFE CYCLE ENERGY ANALYSIS (CONT'D)

b. Life Cycle Cost Summary

Table 7.6 is a summary of the Life Cycle Cost Analysis of each alternative showing the estimated first cost, the present worth of life cycle cost savings, the breakeven point or payback of first cost in years, the percent energy savings, and the energy consumption in Btu/gross square foot of building area/degree day of each alternative.

M.S.U. REID HALL
BASEMENT FLOOR
BOZEMAN MONTANA

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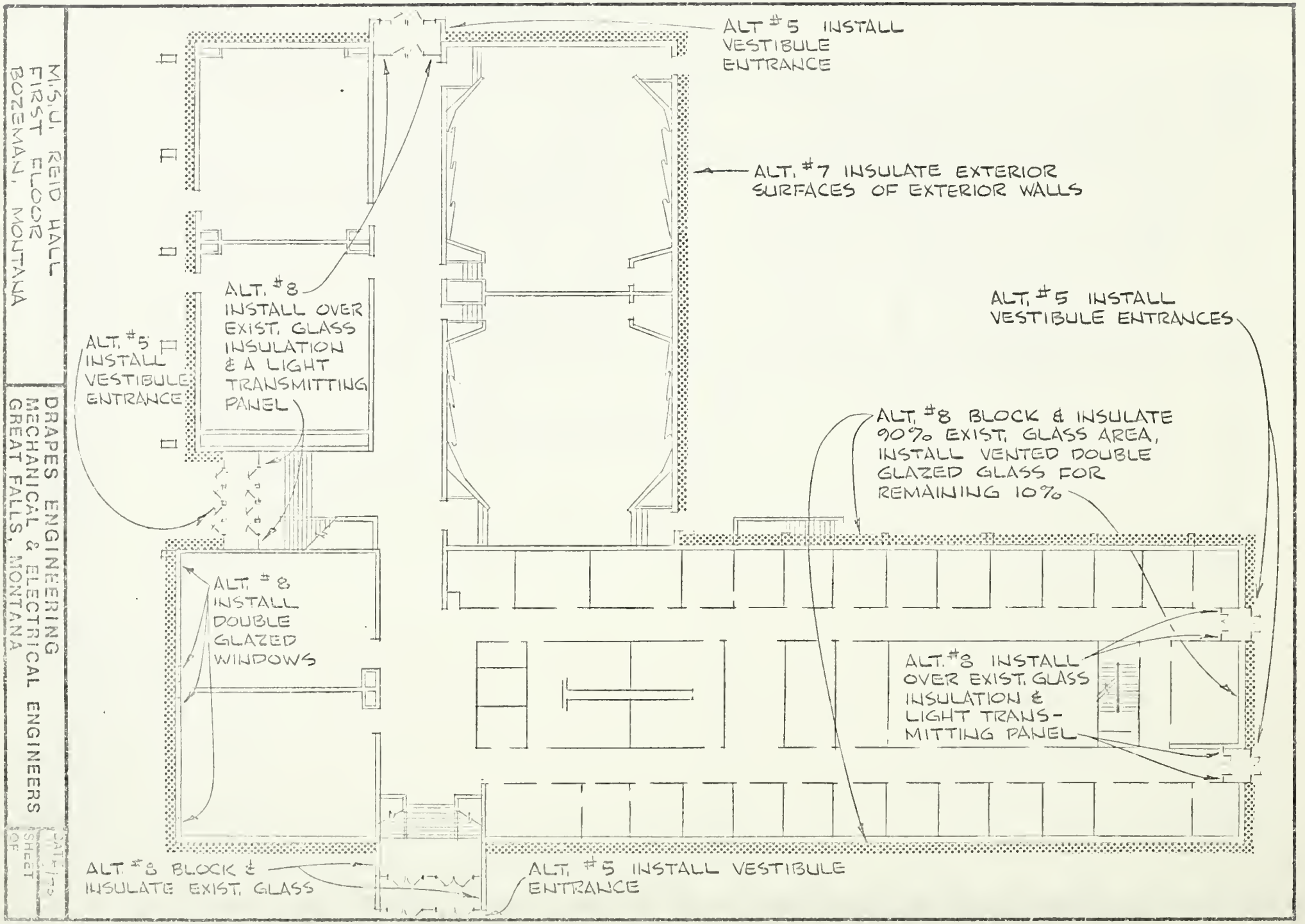
ALT #5 INSTALL VESTIBULE ENTRANCE
ALT. #7 INSULATE EXTERIOR SURFACES OF EXTERIOR WALLS
ALT. #8 INSTALL OVER EXIST. GLASS INSULATION & A LIGHT TRANSMITTING PANEL
ALT. #5 INSTALL VESTIBULE ENTRANCE
ALT. #5 INSTALL VESTIBULE ENTRANCES
ALT. #8 BLOCK & INSULATE 90% EXIST. GLASS AREA, INSTALL VENTED DOUBLE GLAZED GLASS FOR REMAINING 10%
ALT. #8 INSTALL DOUBLE GLAZED WINDOWS
ALT. #8 INSTALL OVER EXIST. GLASS INSULATION & LIGHT TRANS-MITTING PANEL
ALT. #8 BLOCK & INSULATE EXIST. GLASS
ALT. #5 INSTALL VESTIBULE ENTRANCE
M.S.U. REID HALL
FIRST FLOOR
BOZEMAN, MONTANA
DRAPES ENGINEERING
MECHANICAL & ELECTRICAL ENGINEERS
GREAT FALLS, MONTANA
DATE 1-75
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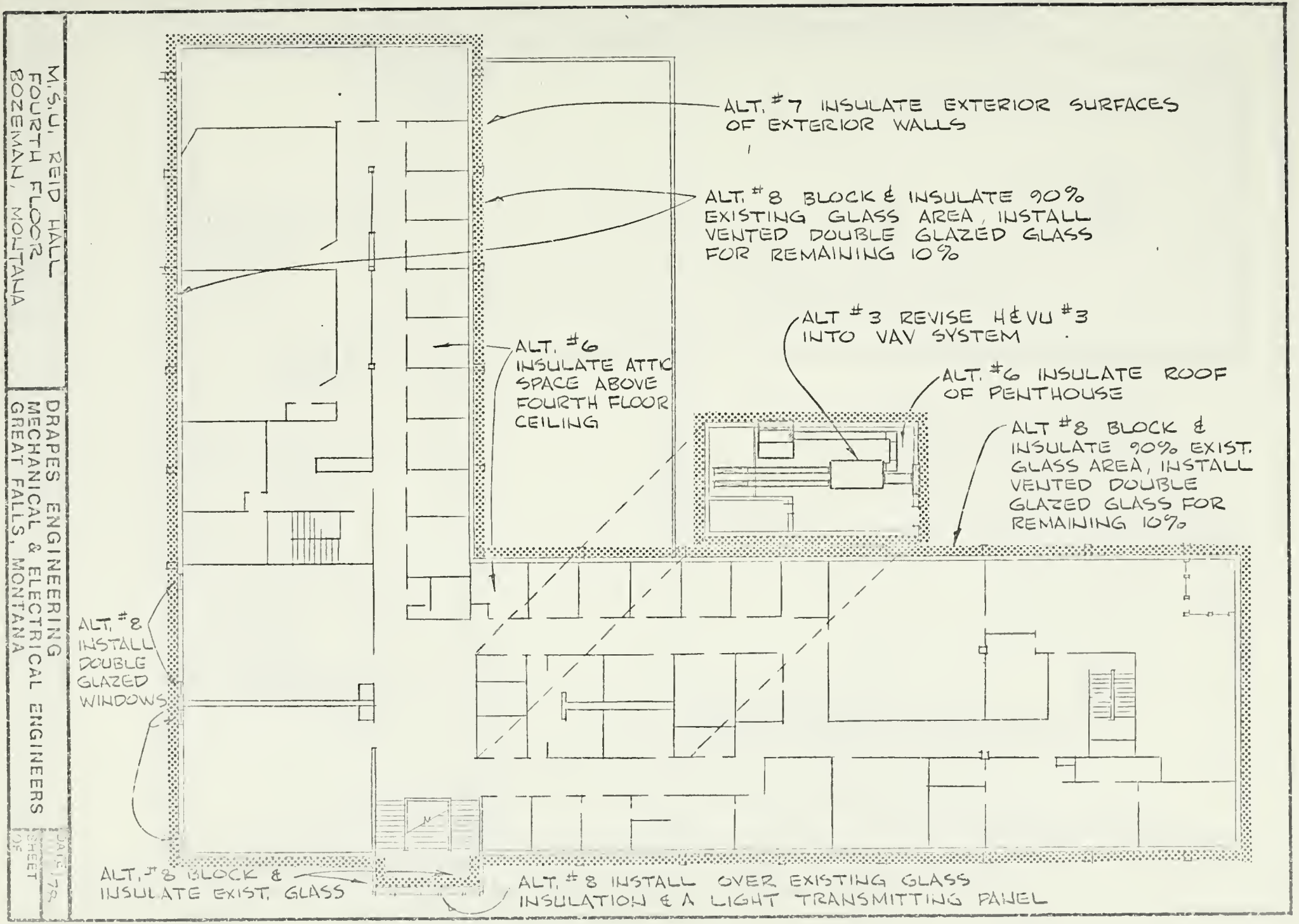
ALT. #7 INSULATE EXTERIOR SURFACES OF EXTERIOR WALLS
ALT. #8 BLOCK & INSULATE 90% EXISTING GLASS AREA, INSTALL VENTED DOUBLE GLAZED GLASS FOR REMAINING 10%
ALT #3 REVISE H&VU #3 INTO VAV SYSTEM
ALT. #6 INSULATE ROOF OF PENTHOUSE
ALT. #6 INSULATE ATTIC SPACE ABOVE FOURTH FLOOR CEILING
ALT #8 BLOCK & INSULATE 90% EXIST. GLASS AREA, INSTALL VENTED DOUBLE GLAZED GLASS FOR REMAINING 10%
ALT. #8 INSTALL DOUBLE GLAZED WINDOWS
ALT. #8 BLOCK & INSULATE EXIST. GLASS
ALT. #8 INSTALL OVER EXISTING GLASS INSULATION & A LIGHT TRANSMITTING PANEL
M.S.U. REID HALL
FOURTH FLOOR
BOZEMAN, MONTANA
DRAPES ENGINEERING
MECHANICAL & ELECTRICAL ENGINEERS
GREAT FALLS, MONTANA
DATE 1-78
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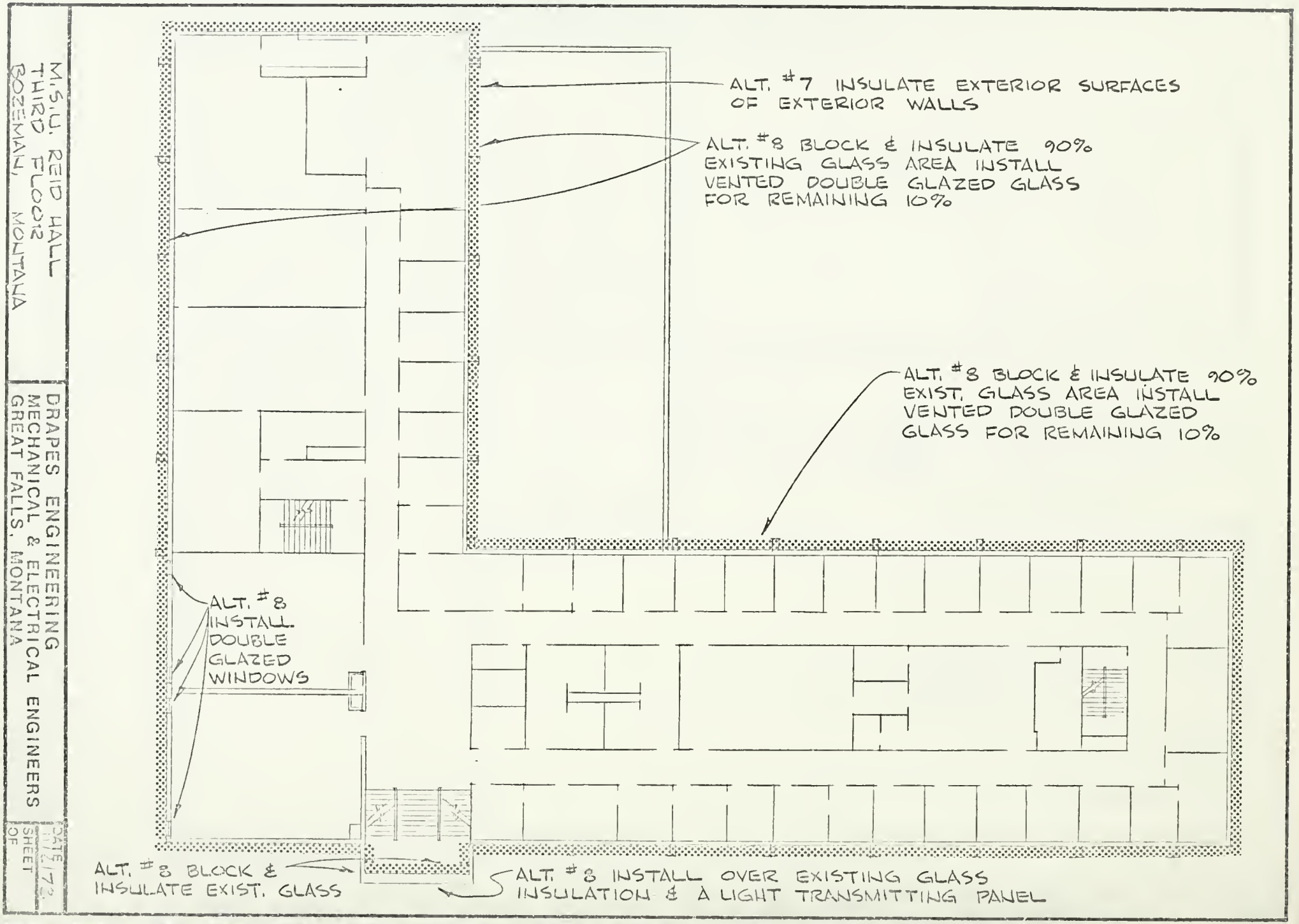
M.S.U. REID HALL
THIRD FLOOR
BOZEMAN, MONTANA
DRAPES ENGINEERING
MECHANICAL & ELECTRICAL ENGINEERS
GREAT FALLS, MONTANA
DATE 11/2/72
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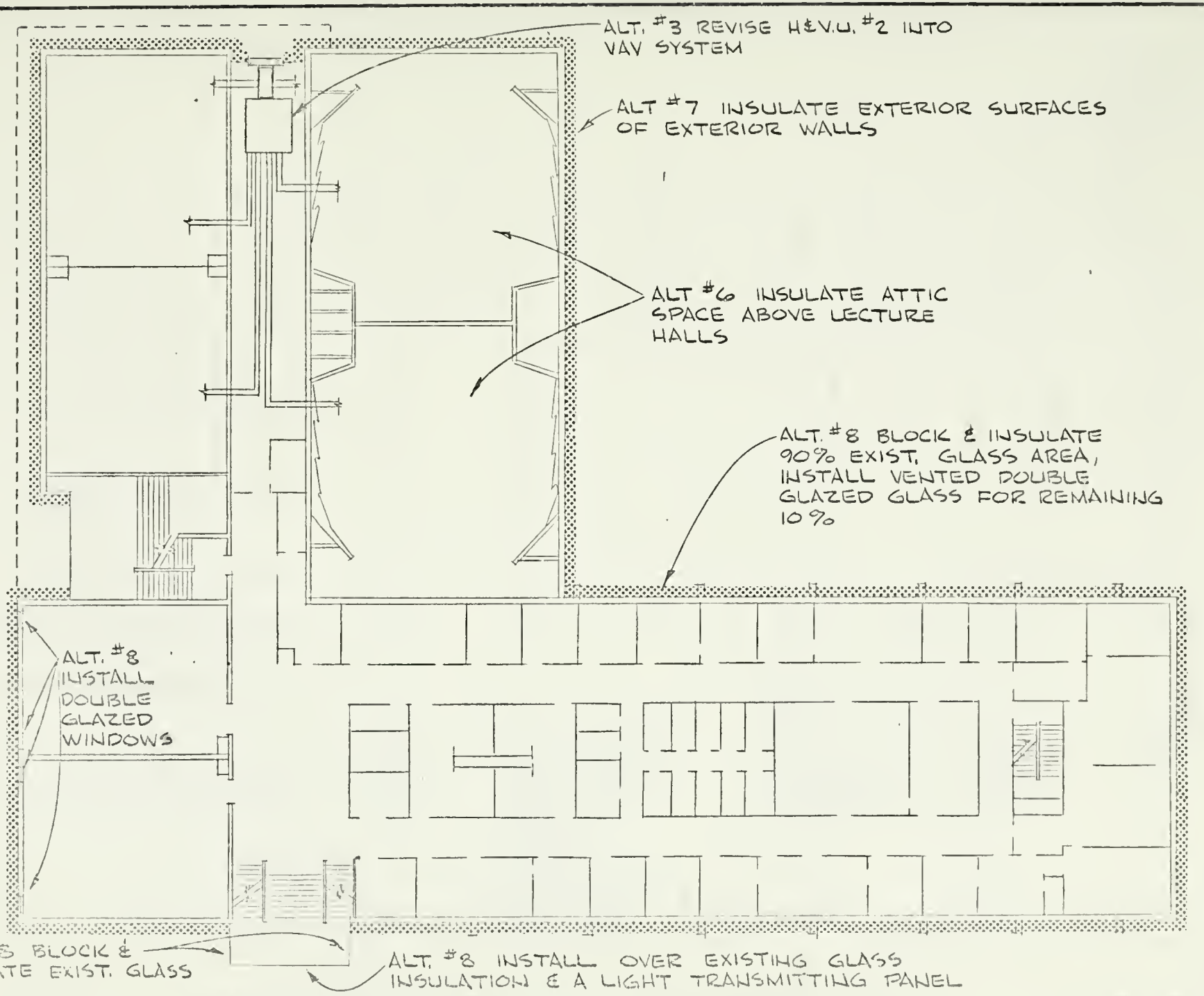
OF
ALT. #7 INSULATE EXTERIOR SURFACES OF EXTERIOR WALLS
ALT. #8 BLOCK & INSULATE 90% EXISTING GLASS AREA INSTALL VENTED DOUBLE GLAZED GLASS FOR REMAINING 10%
ALT. #8 BLOCK & INSULATE 90% EXIST. GLASS AREA INSTALL VENTED DOUBLE GLAZED GLASS FOR REMAINING 10%
ALT. #8 INSTALL DOUBLE GLAZED WINDOWS
ALT. #8 BLOCK & INSULATE EXIST. GLASS
ALT. #8 INSTALL OVER EXISTING GLASS INSULATION & A LIGHT TRANSMITTING PANEL


ALT. #3 REVISE H&V.U. #2 INTO VAV SYSTEM
ALT #7 INSULATE EXTERIOR SURFACES OF EXTERIOR WALLS
ALT #6 INSULATE ATTIC SPACE ABOVE LECTURE HALLS
ALT. #8 BLOCK & INSULATE 90% EXIST. GLASS AREA, INSTALL VENTED DOUBLE GLAZED GLASS FOR REMAINING 10%
ALT. #8 INSTALL DOUBLE GLAZED WINDOWS
ALT. #8 BLOCK & INSULATE EXIST. GLASS
ALT. #8 INSTALL OVER EXISTING GLASS INSULATION & A LIGHT TRANSMITTING PANEL

M.S.U. REID HALL
SECOND FLOOR
BOZEMAN, MONTANA

DRAPES ENGINEERING
MECHANICAL & ELECTRICAL ENGINEERS
GREAT FALLS, MONTANA

DATE
SHEET
OF

7.65

TABLE 7.6

LIFE CYCLE COST SUMMARY

REID HALL

| Alt. | Alternative Description | First Cost ($1000's) | Present Worth of Life Cycle Cost Savings ($1000's) | | Breakeven On First Cost (Yr) | | Percent Energy Savings | EUI BTU / GSF-DD |
|---|---|---|---|---|---|---|---|---|
| | | | Min. | Max. | Min. | Max. | | |
| 1 | Existing Buiding | - | - | - | - | - | - | 13.53 |
| 2 | Convert dual duct high velocity unit into VAV unit. | 139 | -2 | 142 | 28 | >40 | 8.1 | 12.43 |
| 3 | Convert lecture room H&V units into VAV. | 25 | 121 | 261 | 8 | 9 | 8.7 | 12.36 |
| 4 | Install controls on mechanical/photography exhaust fan. | .5 | 13 | 24 | 3 | 3 | .8 | 13.42 |
| 5 | Install vestibule entrances. | 12 | 2 | 14 | 27 | 36 | .8 | 13.42 |
| 6 | Insulate attic spaces. | 29 | 37 | 94 | 18 | 21 | 4.0 | 12.99 |
| 7 | Insulate exterior surface of exterior walls. | 98 | 73 | 218 | 21 | 26 | 10.1 | 12.16 |
| 8 | Modify glass surfaces. | 145 | 90 | 291 | 22 | 28 | 14.0 | 11.64 |

3. LIFE CYCLE CONSERVATION RECOMMENDATIONS

a. The following recommendations, in order of priority, are to conserve energy and reduce the Life Cycle owning and operating costs of the MSU Reid Hall.

1. Alternative #4

Install a thermostatic switch interlocked with an occupied/unoccupied switch to control the mechanical/photography rooms' exhaust fan. This provides an estimated energy savings of .8% for an investment of $500.00 with a payback of three years.

2. Alternative #3

Revise heating and ventilating Units #1 and #2 into VAV ventilating only units. This provides an estimated energy savings of 8.7% for an investment of $25,200.00 with a payback of 8 to 9 years (minimum to maximum).

3. Alternative #6

Insulate the attic area above lecture room 105 and 108 and the attic area above the fourth floor with thirteen inches of blown-in insulation. Insulate the penthouse roof with six inches of beadboard when the penthouse roof is replaced. In rooms 105 and 108, insulate the nearly vertical ceiling portions, the second floor's wall common to the attic and the third floor's floor common to the attic with ten inches of beadboard. This provides an estimated energy savings of 4.0% for an investment of $29,200.00 with a payback of 18 to 21 years.

3. LIFE CYCLE CONSERVATION RECOMMENDATIONS (CONT'D)

4. Alternative #7

Insulate the exterior walls on the exterior surface with six inches of glued-up beadboard covered with a finish of stucco. This provides an estimated energy savings of 10.1% for an investment of $97,500.00 with a payback of 21 to 26 years.

5. Alternative #8

Replace existing window areas by blocking and insulating the opening or installing new double-glazed window units. This provides an estimated energy savings of 14.0% for an investment of $145,000.00 with a payback of 22 to 28 years.

6. Alternative #5

Install double-doored vestibules on all entrances. This provides an estimated energy savings of .8% for an investment of $11,600.00 with a payback of 27 to 36 years.

7. Alternative #2

Revise heating and ventilating Unit #3 into VAV ventilating only unit. This provides an estimated energy savings of 8.1% for an investment of $139,200.00 with a payback of 28 years to a time greater than the estimated economic building life.

## H. EMPLOYMENT SECURITY BUILDING

### 1. BUILDING DESCRIPTION

#### a. General

The original Employment Security Building was built in 1963 with an addition in 1972 for a total floor area of 49,621 square feet. Both sections have four floors aboveground plus a basement and rooftop penthouse for mechanical equipment. The basement in the original building contains a mechanical room, lunchroom, kitchen, supply, and storage rooms. The basement in the addition contains a mechanical room, computer room, and storage. The upper four floors of both sections are used for office space.

#### b. Building Envelope

Both sections of the building have built-up roofs. The roof on the older section contains five inches of insulating concrete. The addition's roof has a minimum of one-inch rigid insulation sloped away from the drains for an effective overall depth of 1.5 inches. Walls for the original section are uninsulated, nine-inch concrete.

The addition's walls are metal studs or CMU's with 3.5 inches of fiberglass batt insulation. Windows in both sections are single-glazed. The southern wall of the older section has motor driven external sun controls.

#### c. Heating, Ventilation, and Air-Conditioning System

A single zone unit with an air-cooled condensing unit in the basement of the addition conditions the computer room. Heating and cooling for the rest of the addition are provided by a central boiler and chiller

1. BUILDING DESCRIPTION

via fan-coil units. A multizone unit supplies ventilation air as well as heating and cooling.

The original section has a steam boiler for heating and central chiller for cooling. Distribution is via fan-coil units. Ventilation and additional cooling are provided to the upper four floors by a single zone unit with 100% outdoor air. A second unit in the basement provides fresh air to the lunchroom.

Mechanical cooling is not being used in an effort to reduce energy consumption.

2. LIFE CYCLE ENERGY ANALYSIS

a. Description of Alternatives

The following are energy conserving alternatives that were investigated for the Employment Security Building.

Alternative #1

This alternative is the existing building "as is". Alternative #1 is the basis of comparison for the other alternatives.

Alternative #2

Install dampers in boiler flues to reduce standby losses.

Alternative #3

Change the multizone unit in the addition to variable air volume.

Alternative #4

Provide return air and individual floor zoning to the ventilation system in the original building instead of bringing in 100% outdoor air and exhausting it.

Alternative #5

Insulate the exterior walls of the original building section with eight inches of beadboard insulation and stucco finish.

Alternative #6

Add seven inches of beadboard insulation when the existing roof is replaced.

Alternative #7

Block 75% of the window area with eight inches of beadboard and stucco finish. Install operable double-glazed units in the remaining openings.

2. LIFE CYCLE ENERGY ANALYSIS (CONT'D)

b. Life Cycle Cost Summary

Table 7.7 is a summary of the Life Cycle Cost Analysis of each alternative showing the estimated first cost, the present worth of life cycle cost savings, the breakeven point or payback of first cost in years, the percent energy savings, and the energy consumption in Btu/gross square foot of building area/degree day of each alternative.

EMPLOYMENT SECURITY BUILDING
FIRST FLOOR
HELENA, MONTANA

DRAPES ENGINEERING
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DATE 12-4-73
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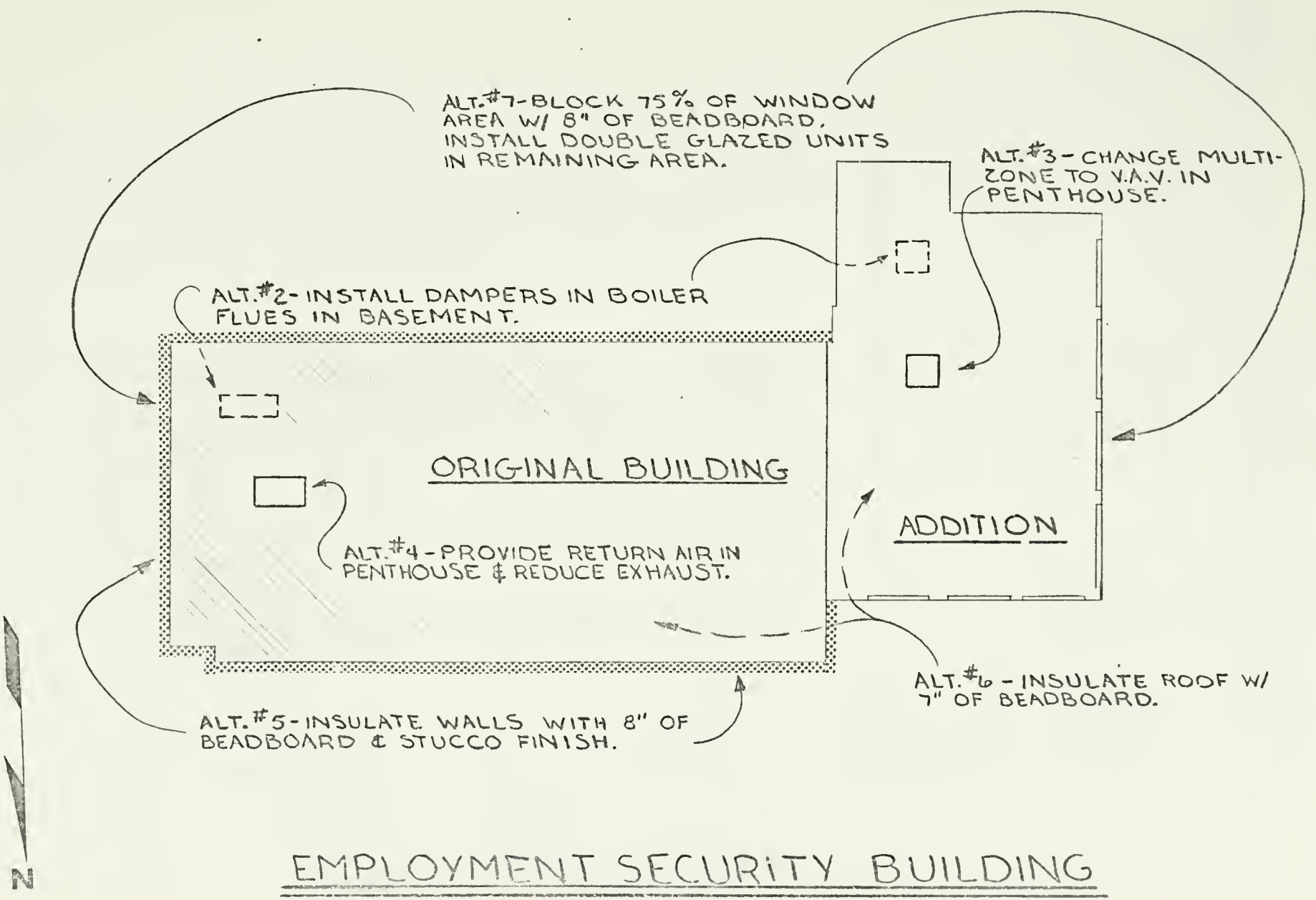

ALT.#7-BLOCK 75% OF WINDOW AREA W/ 8" OF BEADBOARD, INSTALL DOUBLE GLAZED UNITS IN REMAINING AREA.
ALT.#3-CHANGE MULTI-ZONE TO V.A.V. IN PENTHOUSE.
ALT.#2-INSTALL DAMPERS IN BOILER FLUES IN BASEMENT.
ORIGINAL BUILDING
ADDITION
ALT.#4-PROVIDE RETURN AIR IN PENTHOUSE & REDUCE EXHAUST.
ALT.#6-INSULATE ROOF W/ 7" OF BEADBOARD.
ALT.#5-INSULATE WALLS WITH 8" OF BEADBOARD & STUCCO FINISH.
N

# EMPLOYMENT SECURITY BUILDING

TABLE 7.7

LIFE CYCLE COST SUMMARY

EMPLOYMENT SECURITY DIVISION

| Alt. | Alternative Description | First Cost ($1000's) | Present Worth of Life Cycle Cost Savings ($1000's) | | Breakeven On First Cost (Yr) | | Percent Energy Savings | EUI BTU / GSF-DD |
|---|---|---|---|---|---|---|---|---|
| | | | Min. | Max. | Min. | Max. | | |
| 1 | Existing Building | - | - | - | - | - | - | 16.52 |
| 2 | Flue Dampers | 3.4 | 18 | 38 | 8 | 9 | 2.1 | 16.17 |
| 3 | VAV - The Addition | 13 | 30 | 77 | 13 | 15 | 4.3 | 15.82 |
| 4 | Return Air | 8 | 47 | 97 | 8 | 8 | 5.4 | 15.62 |
| 5 | Insulate Wall | 47 | 120 | 271 | 13 | 15 | 16.5 | 13.80 |
| 6 | Insulate Roof | 17 | 25 | 63 | 17 | 20 | 4.2 | 15.84 |
| 7 | Block Windows and Double-Glaze | 65 | 164 | 370 | 13 | 15 | 22.5 | 12.80 |

3. LIFE CYCLE CONSERVATION RECOMMENDATIONS

a. The following recommendations, in order of priority, are to conserve energy and reduce the Life Cycle owning and operating costs of the Employment Security Building.

1. Alternative #4

Provide return air and individual floor zoning to the ventilation system in the original building. Estimated energy savings are 5.4% with a payback of eight years for an investment of $8,000.00.

2. Alternative #2

Install dampers in the boiler flues to reduce standby losses. Estimated energy savings are 2.1% with a payback of eight to nine years (minimum to maximum) for an investment of $3,400.00.

3. Alternative #3

Change the multizone unit in the addition to variable air volume. Estimated energy savings are 4.3% with a payback of 13 to 15 years for an investment of $13,000.00.

4. Alternative #5

Insulate the exterior walls of the original building section with eight inches of beadboard insulation and stucco finish. Estimated energy savings are 16.5% with a payback of 13 to 15 years for an investment of $47,000.00.

5. Alternative #7

Block 75% of the window area with eight inches of beadboard and stucco finish. Install operable double-glazed units in the remaining area. Estimated energy savings are 22.5% with a payback of 13 to 15 years for an investment of $65,000.00.

3. LIFE CYCLE CONSERVATION RECOMMENDATIONS (CONT'D)

6. Alternative #6

Add seven inches of beadboard insulation when the existing roof is replaced. Estimated energy savings are 22.5% with a payback of 17 to 20 years for an investment of $17,000.00.

1. BUILDING DESCRIPTION

a. General

The Helena Armory Headquarters has a total floor area of 48,854 square feet. The first and second floor contain perimeter offices and a drill hall that extends through both floors. The basement, which is partially below grade, is used for parking and storage with some office space and the mechanical room. A partial lower level below the west end of the basement floor contains some office space and emergency communications equipment.

b. Building Envelope

The building has a built-up roof with 1/2-inch insulation board. Walls are uninsulated twelve-inch concrete. Single-pane glass is used throughout the building. Windows and doors are poorly sealed.

c. Heating, Ventilation, and Air-Conditioning System

The original system was steam heat from a coal-fired boiler with perimeter radiators and fan-coil units. The boiler has since been converted to natural gas. Controls are inadequate and part of the building overheats while other portions receive insufficient heat.

Mechanical cooling is provided for some of the offices by decentralized window units.

2. LIFE CYCLE ENERGY ANALYSIS

a. Description of Alternatives

The following are energy conserving alternatives that were investigated for the Helena Armory Headquarters.

Alternative #1

This alternative is the existing building "as is". Alternative #1 is the basis of comparison for the other alternatives.

Alternative #2

Install individual room thermostats with night setback capability for better temperature control.

Alternative #3

Add eight inches of beadboard insulation when the existing roof is replaced.

Alternative #4

Add eight inches of beadboard insulation with a finished gypsum board cover to the inside of exterior walls.

Alternative #5

Block 75% of the window area with eight inches of beadboard and a stucco finish. Install openable double-glazed units in the remaining openings.

Alternative #6

Install a damper in the boiler flue to reduce standby losses. Replace standby pilot with electric ignition.

Alternative #7

Replace existing boiler insulation with twelve inches of rigid glass fibre insulation.

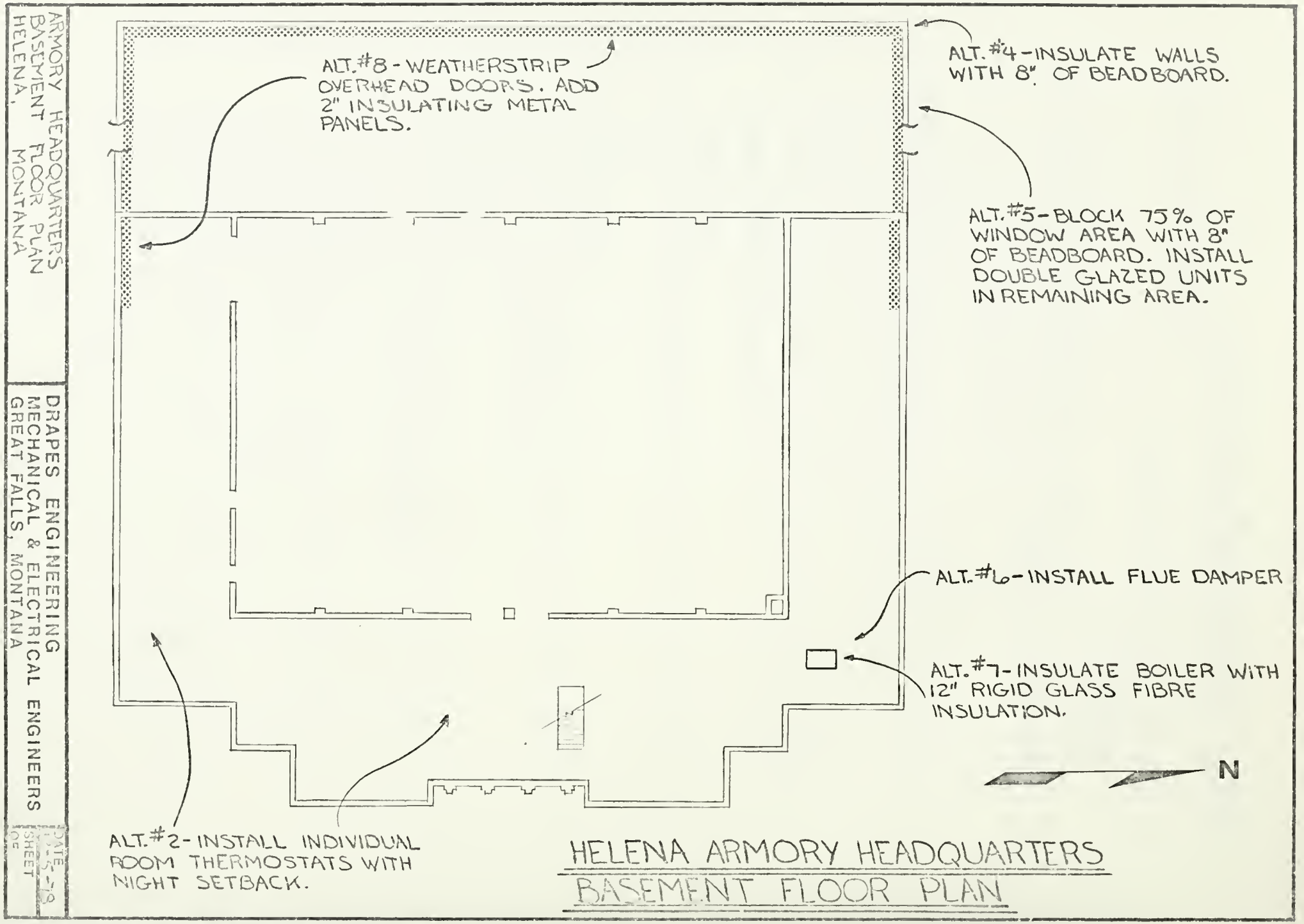
2. LIFE CYCLE ENERGY ANALYSIS (CONT'D)

Alternative #8

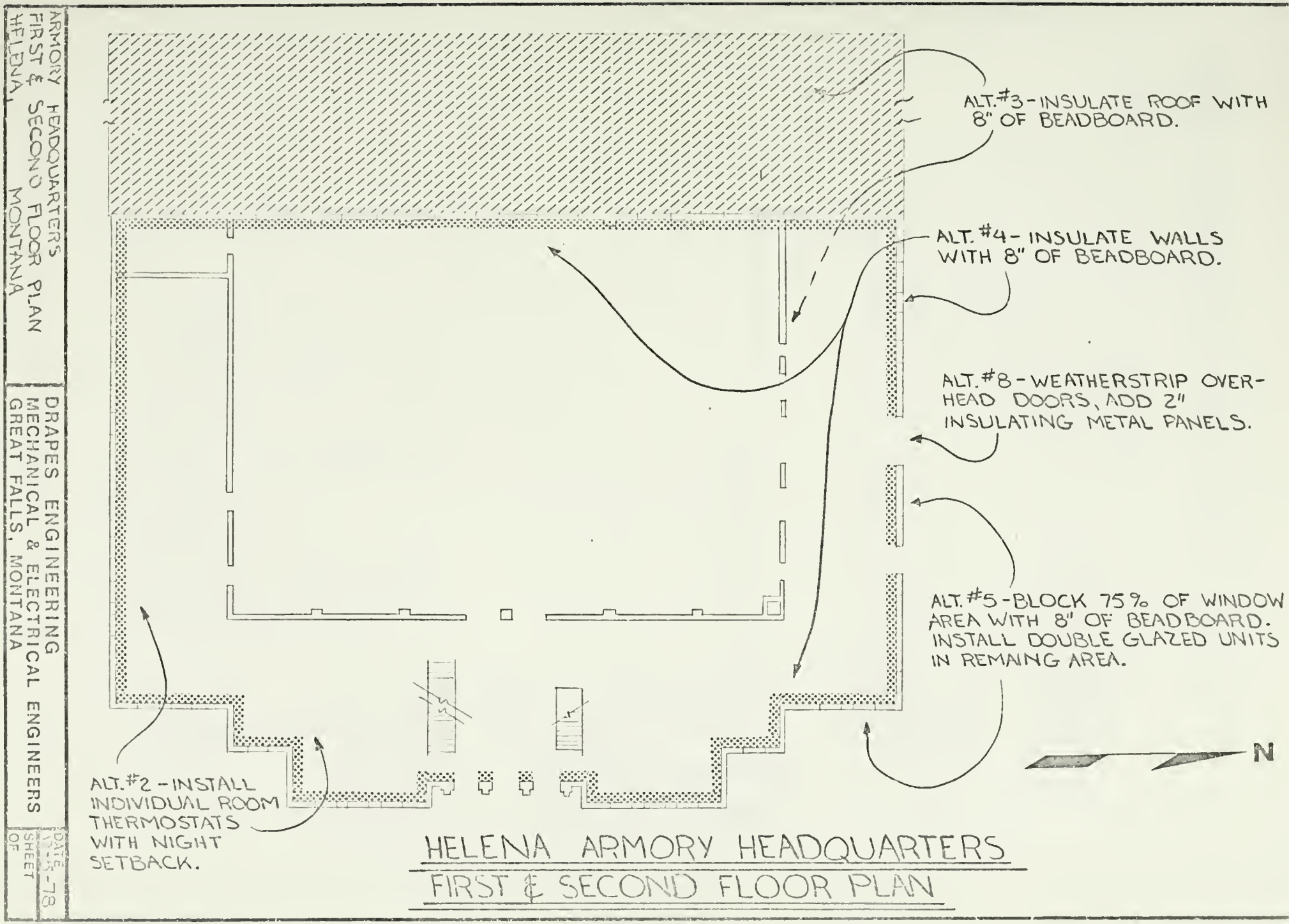
Weatherstrip around overhead doors and add two-inch insulating metal panels to door surfaces.

b. Life Cycle Cost Summary

Table 7.8 is a summary of the Life Cycle Cost Analysis of each alternative showing the estimated first cost, the present worth of life cycle cost savings, the breakeven point or payback of first cost in years, the percent energy savings, and the energy consumption in Btu/gross square foot of building area/degree day of each alternative.


ALT.#8 - WEATHERSTRIP OVERHEAD DOORS. ADD 2" INSULATING METAL PANELS.
ALT.#4 - INSULATE WALLS WITH 8" OF BEADBOARD.
ALT.#5 - BLOCK 75% OF WINDOW AREA WITH 8" OF BEADBOARD. INSTALL DOUBLE GLAZED UNITS IN REMAINING AREA.
ALT.#6 - INSTALL FLUE DAMPER
ALT.#7 - INSULATE BOILER WITH 12" RIGID GLASS FIBRE INSULATION.
N
ALT.#2 - INSTALL INDIVIDUAL ROOM THERMOSTATS WITH NIGHT SETBACK.
HELENA ARMORY HEADQUARTERS
BASEMENT FLOOR PLAN
ARMORY HEADQUARTERS
BASEMENT FLOOR PLAN
HELENA, MONTANA
DRAPES ENGINEERING
MECHANICAL & ELECTRICAL ENGINEERS
GREAT FALLS, MONTANA
DATE
SHEET
OF

7.80


ALT.#3 - INSULATE ROOF WITH 8" OF BEADBOARD.
ALT.#4 - INSULATE WALLS WITH 8" OF BEADBOARD.
ALT.#8 - WEATHERSTRIP OVER-HEAD DOORS, ADD 2" INSULATING METAL PANELS.
ALT.#5 - BLOCK 75% OF WINDOW AREA WITH 8" OF BEADBOARD. INSTALL DOUBLE GLAZED UNITS IN REMAING AREA.
ALT.#2 - INSTALL INDIVIDUAL ROOM THERMOSTATS WITH NIGHT SETBACK.
N
HELENA ARMORY HEADQUARTERS
FIRST & SECOND FLOOR PLAN

ARMORY HEADQUARTERS
FIRST & SECOND FLOOR PLAN
HELENA, MONTANA

DRAPES ENGINEERING
MECHANICAL & ELECTRICAL ENGINEERS
GREAT FALLS, MONTANA

DATE 12-5-78
SHEET
OF

TABLE 7.8

LIFE CYCLE COST SUMMARY

HELENA ARMORY HEADQUARTERS

| Alt. | Alternative Description | First Cost ($1000's) | Present Worth of Life Cycle Cost Savings ($1000's) | | Breakeven On First Cost (Yr) | | Percent Energy Savings | EUI BTU / GSF-DD |
|---|---|---|---|---|---|---|---|---|
| | | | Min. | Max. | Min. | Max. | | |
| 1 | Existing Building | - | - | - | - | - | - | 15.64 |
| 2 | Thermostats & Night Setback | 14 | 105 | 191 | 6 | 6 | 16.2 | 13.10 |
| 3 | Insulate Roof | 41 | 152 | 292 | 9 | 10 | 26.4 | 11.52 |
| 4 | Insulate Wall | 36 | 73 | 153 | 13 | 15 | 15.0 | 13.29 |
| 5 | Block Windows & Double-Glaze | 19 | 129 | 238 | 6 | 6 | 20.4 | 12.46 |
| 6 | Flue Damper | 1.7 | 21 | 37 | 4 | 4 | 3.1 | 15.15 |
| 7 | Insulate Boiler | 1.4 | 7.6 | 14 | 7 | 8 | 1.2 | 15.45 |
| 8 | Weatherstrip & Insulate Overhead Doors | 2.3 | 22 | 40 | 5 | 5 | 3.4 | 15.11 |

3. LIFE CYCLE CONSERVATION RECOMMENDATIONS

a. The following recommendations, in order of priority, are to conserve energy and reduce the Life Cycle owning and operating costs of the Helena Armory Headquarters.

1. Alternative #6

Install a damper in the boiler flue and replace the standing pilot with electric ignition. Estimated energy savings are 3.1% with a payback of four years for an investment of $1,694.00.

2. Alternative #8

Weatherstrip around overhead doors and add two-inch insulating metal panels to door surfaces. Estimated energy savings are 3.4% with a payback of five years for an investment of $2,314.00.

3. Alternative #2

Install individual thermostats with night setback. Estimated energy savings are 16.2% with a payback of six years for an investment of $13,668.00.

4. Alternative #5

Block 75% of the window area with eight inches of beadboard and stucco finish. Install operable double-glazed units in the remaining openings. Estimated energy savings are 20.4% with a payback of six years for an investment of $18,751.00.

5. Alternative #7

Reinsulate the boiler shell with twelve inches of rigid glass fibre insulation. Estimated energy savings are 1.2% with a payback of seven to eight years (minimum to maximum) for an investment of $1,431.00.

3. LIFE CYCLE CONSERVATION RECOMMENDATIONS (CONT'D)

6. Alternative #3

Add eight inches of beadboard insulation when the existing roof is replaced. Estimated energy savings are 26.4% with a payback of nine to ten years for an investment of $40,520.00.

7. Alternative #4

Add eight inches of beadboard insulation to the inside of exterior walls. Estimated energy savings are 15% with a payback of 13 to 15 years for an investment of $36,004.00.

1. BUILDING DESCRIPTION

a. General

The Montana Aeronautics Commission Operations Building was built in 1958. A detached garage and building addition were added in 1965 for a total area of 8,557 square feet. Hangar #2 and half of the garage are not heated so the total conditioned area is 6,403 square feet. The main building is used for office space and meeting rooms.

b. Building Envelope

The original building has a built-up roof with three inches of tectum insulation. The walls are seven-inch endset tile or pumice block with one-inch fiberglass insulation. The addition has 3.5 inches of fiberglass insulation above the ceiling. Walls are eight-inch endset tile with two inches of fiberglass insulation. The garage has 3.5 inches of fiberglass insulation over the ceiling and in the center divider. Garage walls are nine-inch insulated block and the doors are uninsulated wood. The hangars have a built-up roof with one-inch rigid insulation. Six inches of fiberglass insulation have been added to hangar ceilings. Hangar doors have two inches of rigid insulation. Hangar walls are seven-inch tile with no insulation. All of the windows in the main building are double-glazed, except operable windows in the old part which are single-glazed.

c. Heating, Ventilation, and Air-Conditioning System

Heat for the main building is supplied by a natural gas-fired boiler and perimeter radiation. A natural gas furnace heats the addition. A unit heater maintains part of the garage above freezing, while the rest is unheated. Two of the hangars are kept above freezing overnight if a

1. BUILDING DESCRIPTION (CONT'D)

morning flight is scheduled but are unheated the rest of the time. The other hangar is used for storage and is not heated. Cooling is available through the central furnace in the addition and by window units in the main building. Use of mechanical cooling has been minimal.

2. LIFE CYCLE ENERGY ANALYSIS

a. Description of Alternatives

The following are energy conserving alternatives that were investigated for the Montana Aeronautics Commission Operations Building.

Alternative #1

This alternative is the existing building "as is". Alternative #1 is the basis of comparison for the other alternatives.

Alternative #2

Install dampers in the boiler and furnace flues to reduce standby losses.

Alternative #3

Apply weatherstripping around hangar doors.

Alternative #4

Add a third layer of glass to existing fixed pane windows.

Alternative #5

Replace single pane operable windows with double-glazed units.

Alternative #6

Add two-inch insulating metal panels to garage doors.

2. LIFE CYCLE ENERGY ANALYSIS (CONT'D)

Alternative #7

Insulate the exterior walls of the main building and the addition with nine inches of beadboard insulation and stucco finish.

Alternative #8

Add seven inches of beadboard insulation to the addition roof and nine inches to the main roof when reroofing.

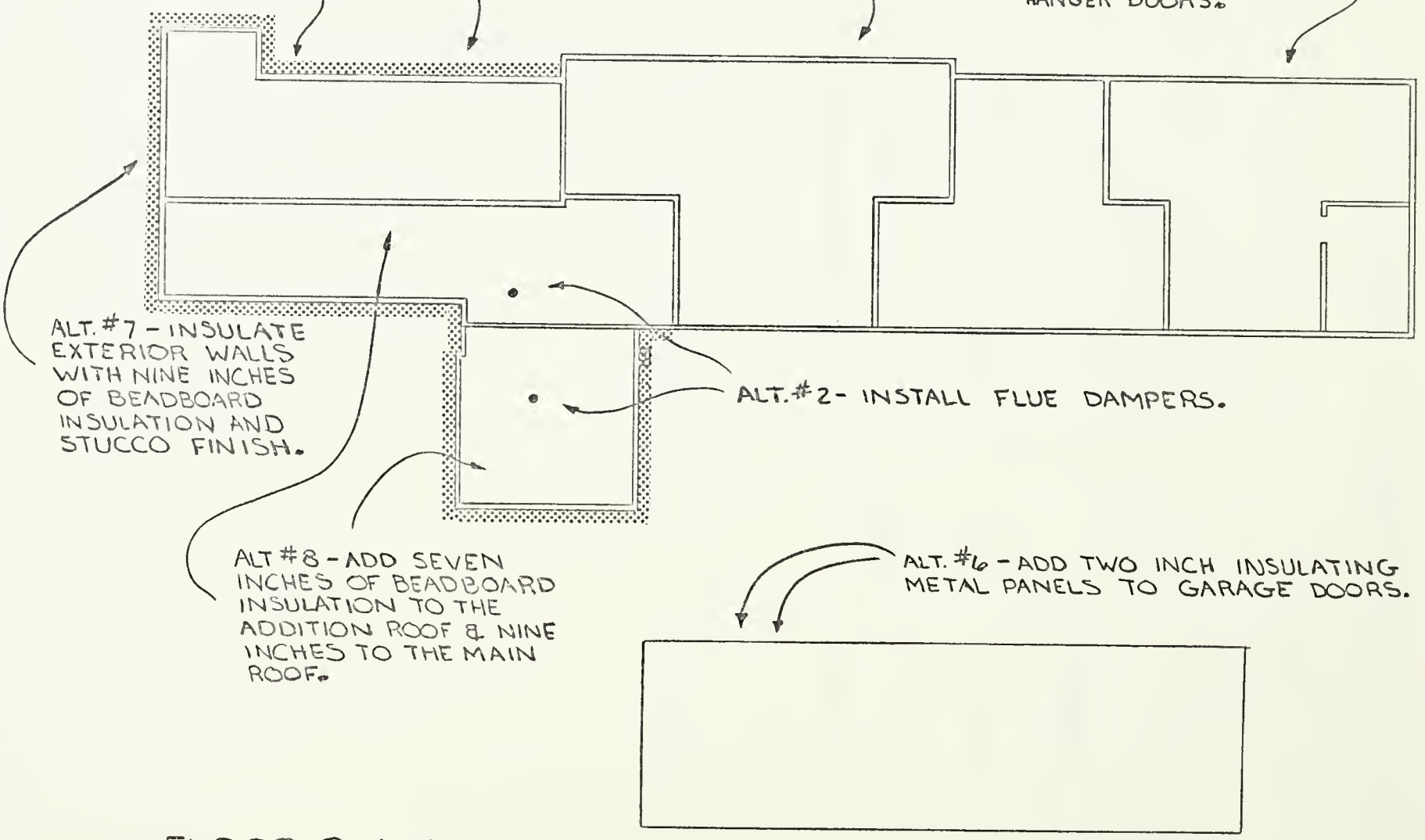
b. Life Cycle Cost Summary

Table 7.9 is a summary of the Life Cycle Cost Analysis of each alternative showing the estimated first cost, the present worth of life cycle cost savings, the breakeven point or payback of first cost in years, the percent energy savings, and the energy consumption in Btu/gross square foot of building area/degree day of each alternative.

MONTANA AERONAUTICS COMMISSION
FLOOR PLAN
HELENA, MONTANA

DRAPES ENGINEERING
MECHANICAL & ELECTRICAL ENGINEERS
GREAT FALLS, MONTANA

DATE 11/23/78
SHEET 1 OF 1


ALT. #5 - REPLACE OPENABLE WINDOWS WITH DOUBLE GLAZED UNITS.
ALT. #4 - ADD THIRD PANE OF GLASS TO FIXED WINDOWS.
ALT. #3 - WEATHERSTRIP HANGER DOORS.
ALT. #7 - INSULATE EXTERIOR WALLS WITH NINE INCHES OF BEADBOARD INSULATION AND STUCCO FINISH.
ALT. #2 - INSTALL FLUE DAMPERS.
ALT #8 - ADD SEVEN INCHES OF BEADBOARD INSULATION TO THE ADDITION ROOF & NINE INCHES TO THE MAIN ROOF.
ALT. #6 - ADD TWO INCH INSULATING METAL PANELS TO GARAGE DOORS.

FLOOR PLAN

TABLE 7.9

LIFE CYCLE COST SUMMARY

MONTANA AERONAUTICS COMMISSION OPERATIONS BUILDING

| Alt. | Alternative Description | First Cost ($1000's) | Present Worth of Life Cycle Cost Savings ($1000's) | | Breakeven On First Cost (Yr) | | Percent Energy Savings | EUI BTU/GSF-DD |
|---|---|---|---|---|---|---|---|---|
| | | | Min. | Max. | Min. | Max. | | |
| 1 | Existing Building | - | - | - | - | - | - | 12.16 |
| 2 | Install Flue Dampers | 1.3 | 1.0 | 3.1 | 21 | 26 | 2.1 | 11.90 |
| 3 | Weatherstrip Hanger Doors | 1.9 | 3.0 | 7.4 | 17 | 20 | 4.6 | 11.60 |
| 4 | Triple-Glazing | 6.8 | -1.7 | 2.9 | 34 | >40 | 4.7 | 11.58 |
| 5 | Double-Glazing | 1.0 | -.9 | .7 | 31 | >40 | .8 | 12.06 |
| 6 | Insulate Garage Doors | 0.8 | 1.0 | 2.7 | 17 | 21 | 1.7 | 11.96 |
| 7 | Insulate Exterior Walls | 6.4 | -.3 | 5.2 | 30 | >40 | 5.7 | 11.47 |
| 8 | Insulate Roof | 5.9 | 5.8 | 16.3 | 19 | 24 | 10.7 | 10.86 |

3. LIFE CYCLE CONSERVATION RECOMMENDATIONS

a. The following recommendations, in order of priority, are to conserve energy and reduce the Life Cycle owning and operating costs of the Montana Aeronautics Commission.

1. Alternative #3

Apply weatherstripping around hangar doors. Estimated energy savings are 4.6% with a payback of 17 to 20 years for an investment of $1,936.00.

2. Alternative #6

Add two-inch insulating metal panels to garage doors. Estimated energy savings are 1.7% with a payback of 17 to 21 years for an investment of $759.00.

3. Alternative #8

Add seven inches of beadboard insulation to the addition roof and nine inches to the main roof when reroofing. Energy savings are 10.7% with a payback of 19 to 24 years for an investment of $5,853.00.

4. Alternative #2

Install dampers in boiler and furnace flues. Estimated energy savings are 2.1% with a payback of 21 to 26 years for an investment of $1,257.00.

5. Alternative #7

Insulate the exterior walls of the main building and the addition with nine inches of beadboard insulation and stucco finish. Estimated energy savings are 5.7% with a payback of 30 years to no payback for an investment of $6,418.00.

3. LIFE CYCLE CONSERVATION RECOMMENDATIONS (CONT'D)

6. Alternative #5

Replace single pane operable windows with double-glazed units. Energy savings are .8% with a payback of 31 years to no payback for an investment of $1,004.00.

7. Alternative #4

Add a third layer of glass to existing fixed pane windows. Estimated energy savings are 4.7% with a payback of 34 years to no payback for an investment of $6,792.00.

1. BUILDING DESCRIPTION

a. General

The Scott Hart Building was designed and used as an office building for the Montana Highway Department. The original section was built in 1936 with an addition in 1957 for a total floor area of 76,290 square feet. The original section has two floors aboveground and a basement. The basement contains the mechanical room, open work area, and office space. The upper floors are used for office space.

The section of the addition that connects to the existing building is used for storage in the basement and lobby area with some office space on the upper three floors. The addition also includes a single level auditorium and a six-story section with offices and a small mechanical room on each floor. A rooftop penthouse contains a mechanical room for the elevator.

b. Building Envelope

Both sections of the building have built-up roofs. The roof on the older section has one-inch of rigid insulation. The roof on the addition had two inches of rigid insulation to which 3-1/2" of rigid foam insulation (R-20) were added as part of a recent reroofing. Walls for the original section are twelve-inch concrete with no insulation. The addition's walls are eight-inch concrete with 1-1/2" of batt insulation and curtain wall panels with 1-1/2" of rigid insulation. Windows in both sections are single-glazed.

1. BUILDING DESCRIPTION (CONT'D)

c. Heating, Ventilation and Air-Conditioning System

The original section is heated by a gas-fired steam boiler via radiators and unit heaters. The addition is also heated by a gas-fired steam boiler with two H&V units on each upper floor plus one in the basement and one for the auditorium. A mixed air setting of $60^{o}$ on the H&V units determines the amount of outdoor air brought into the building. Mechanical cooling has been provided in the addition but is not being used in an effort to reduce energy consumption.

2. LIFE CYCLE ENERGY ANALYSIS

a. Description of Alternatives

The following alternatives were investigated for achieving energy conservation.

Alternative #1

This alternative is the existing building "as is". Alternative #1 is the basis of comparison for the other alternatives.

Alternative #2

Modify H&V units in the addition to minimize fresh air intake except when cooling is required.

Alternative #3

Install dampers in boiler flues to reduce standby losses.

Alternative #4

Replace existing boiler insulation with six inches of rigid fiberglass insulation.

Alternative #5

Add five inches of beadboard insulation when the existing roof on the original building section is replaced.

Alternative #6

Insulate the exterior walls of all building sections with seven inches of beadboard insulation and stucco finish.

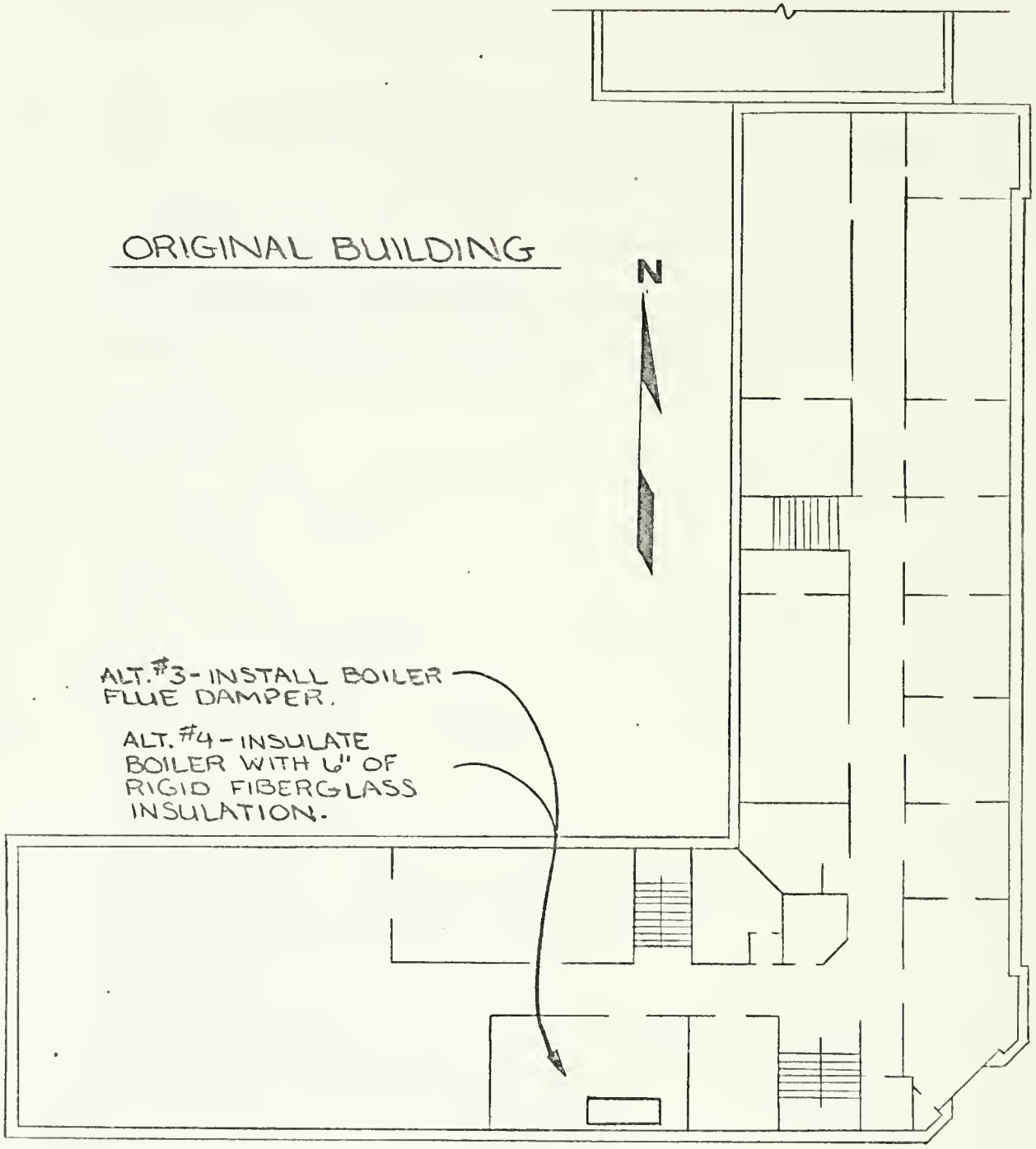
Alternative #7

Block 80% of the window area with seven inches of beadboard and a stucco finish. Install operable double-glazed units in the remaining openings.

2. LIFE CYCLE ENERGY ANALYSIS (CONT'D)

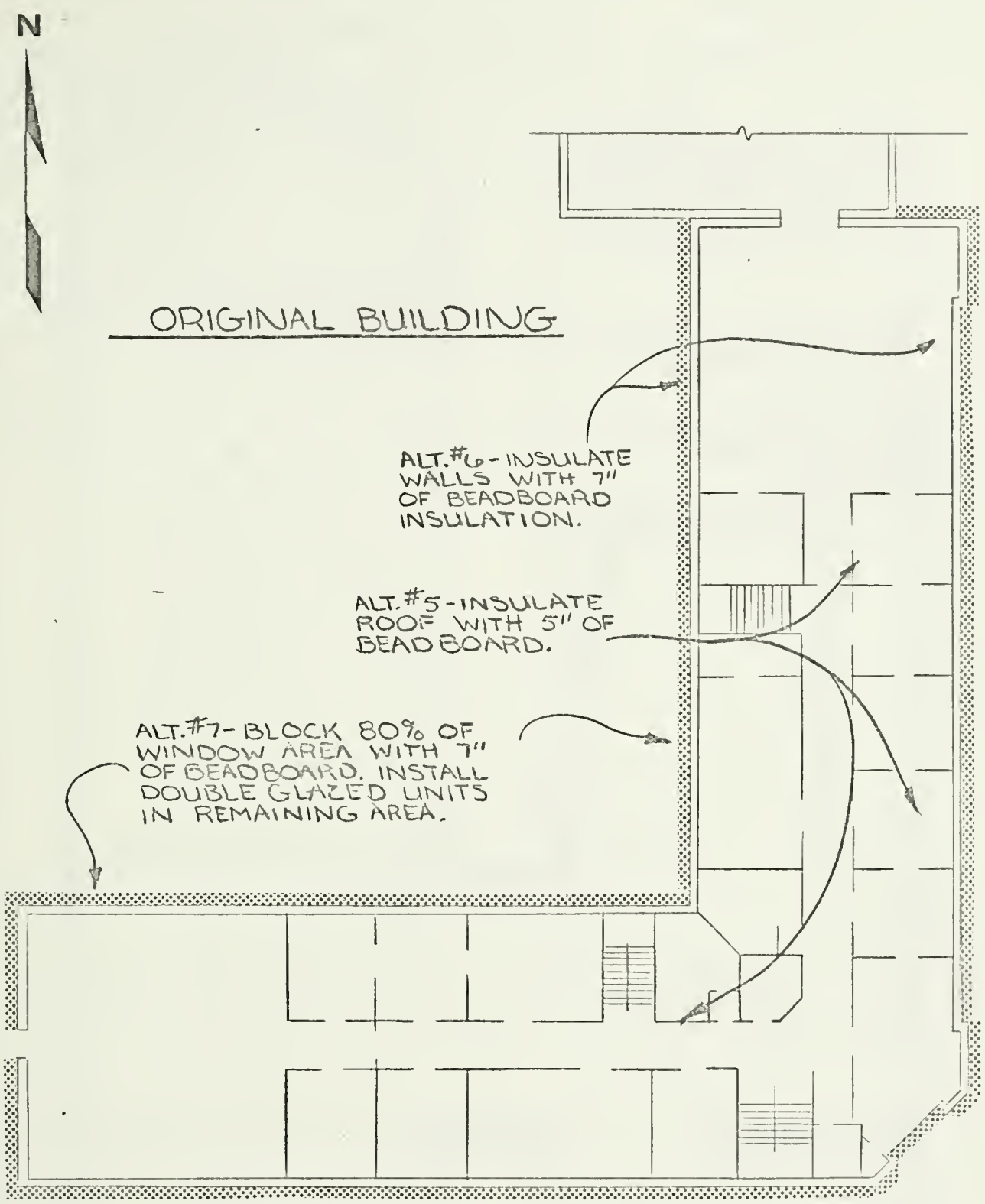
b. Life Cycle Cost Summary

Table 7.10 is a summary of the Life Cycle Cost Analysis of each alternative showing the estimated first cost, the present worth of life cycle cost savings, the breakeven point or payback of first cost in years, the percent energy savings, and the energy consumption in Btu/gross square foot of building area/degree day of each alternative.




# BASEMENT FLOOR - SCOTT HART BLD'G

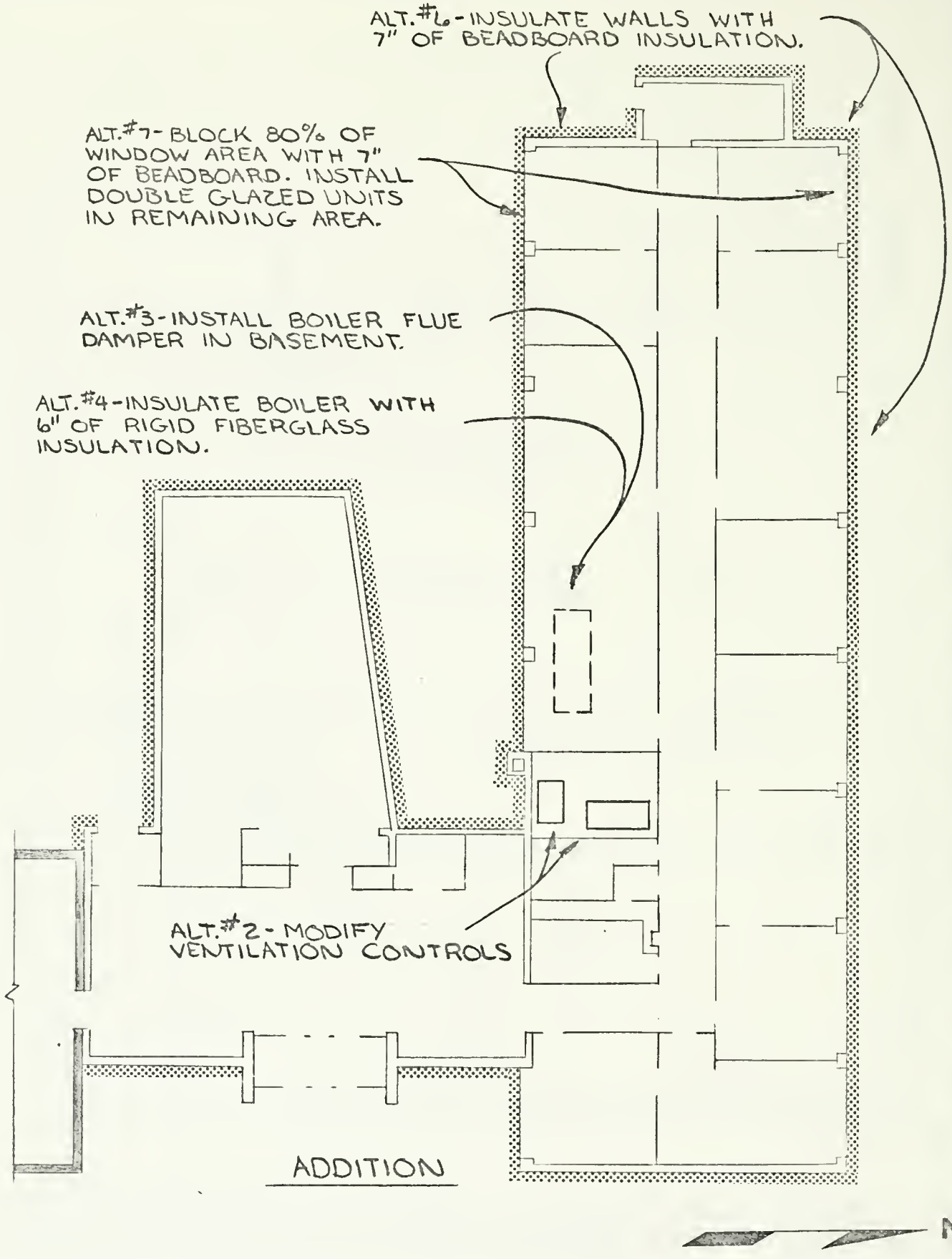
| | | |
|---|---|---|
| SCOTT HART BUILDING<br>BASEMENT FLOOR<br>HELENA, MONTANA | DRAPES ENGINEERING<br>MECHANICAL & ELECTRICAL ENGINEERS<br>GREAT FALLS, MONTANA | DATE 12-23-75<br>SHEET<br>OF |


N
ORIGINAL BUILDING
ALT.#6 - INSULATE WALLS WITH 7" OF BEADBOARD INSULATION.
ALT.#5 - INSULATE ROOF WITH 5" OF BEADBOARD.
ALT.#7 - BLOCK 80% OF WINDOW AREA WITH 7" OF BEADBOARD. INSTALL DOUBLE GLAZED UNITS IN REMAINING AREA.

# FIRST FLOOR - SCOTT HART BUILDING

## SECOND FLOOR SIMILAR

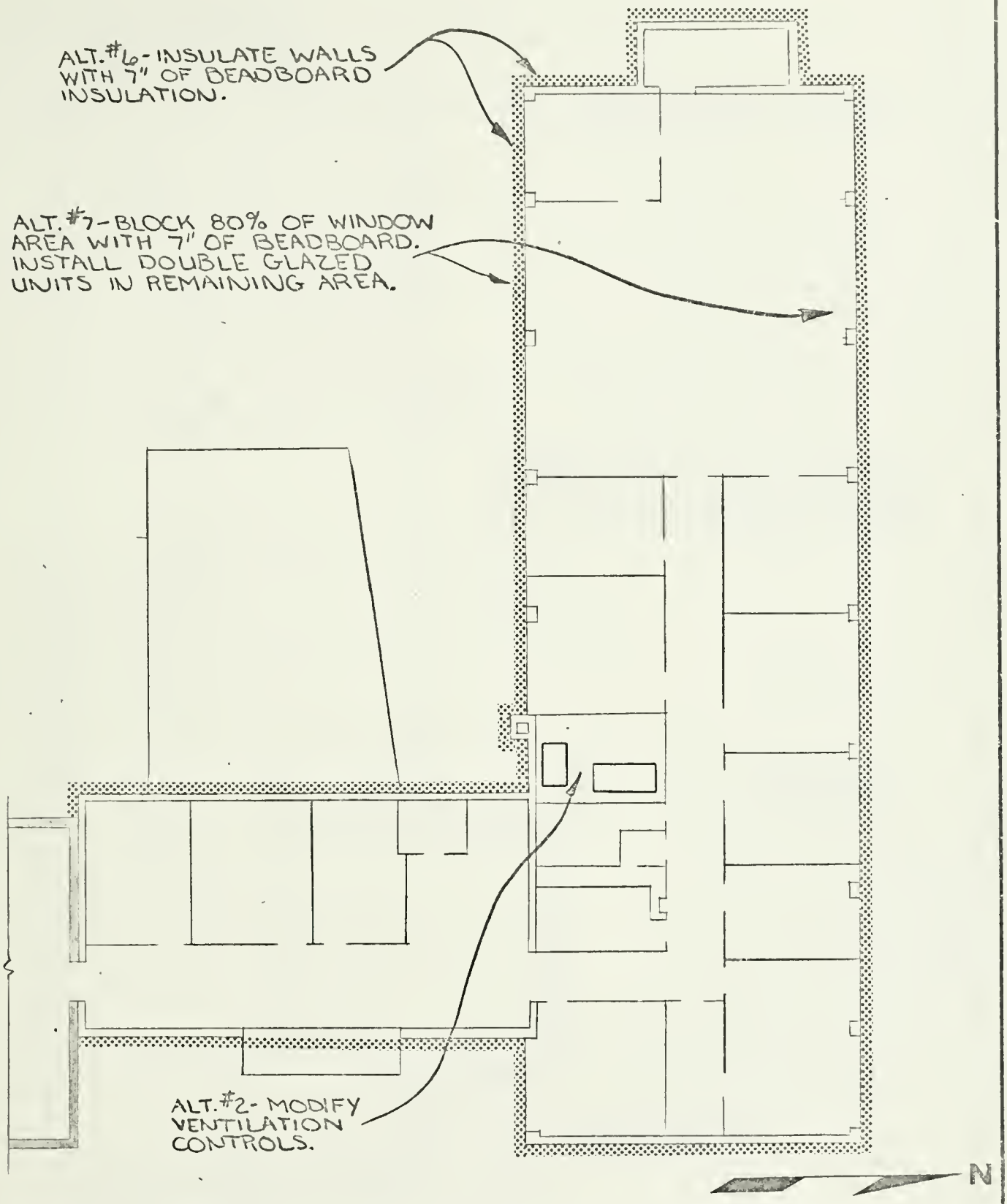
| | | |
|---|---|---|
| SCOTT HART BUILDING<br>FIRST & SECOND FLOORS<br>HELENA, MONTANA | DRAPES ENGINEERING<br>MECHANICAL & ELECTRICAL ENGINEERS<br>GREAT FALLS, MONTANA | DATE 12-20-71<br>SHEET<br>OF |


ALT.#6 - INSULATE WALLS WITH 7" OF BEADBOARD INSULATION.
ALT.#7 - BLOCK 80% OF WINDOW AREA WITH 7" OF BEADBOARD. INSTALL DOUBLE GLAZED UNITS IN REMAINING AREA.
ALT.#3 - INSTALL BOILER FLUE DAMPER IN BASEMENT.
ALT.#4 - INSULATE BOILER WITH 6" OF RIGID FIBERGLASS INSULATION.
ALT.#2 - MODIFY VENTILATION CONTROLS
ADDITION
N

# FIRST FLOOR - SCOTT HART BUILDING

| | | |
|---|---|---|
| SCOTT HART BUILDING<br>FIRST FLOOR PLAN<br>HELENA, MONTANA | DRAPES ENGINEERING<br>MECHANICAL & ELECTRICAL ENGINEERS<br>GREAT FALLS, MONTANA | DATE 2-27-78<br>SHEET<br>OF |

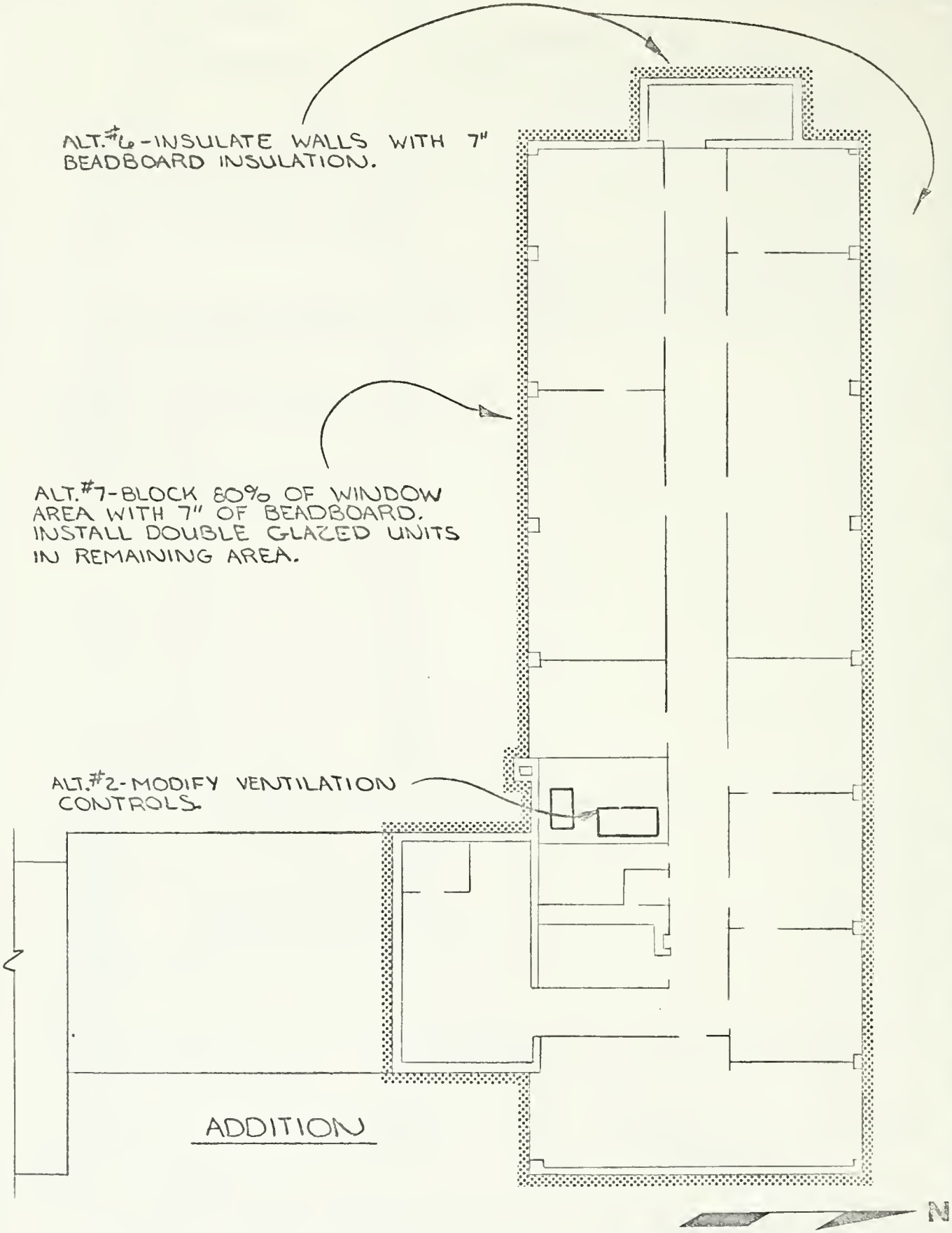
ADDITION


ALT.#6 - INSULATE WALLS WITH 7" OF BEADBOARD INSULATION.
ALT.#7 - BLOCK 80% OF WINDOW AREA WITH 7" OF BEADBOARD. INSTALL DOUBLE GLAZED UNITS IN REMAINING AREA.
ALT.#2 - MODIFY VENTILATION CONTROLS.
N

# SECOND FLOOR - SCOTT HART BUILDING

THIRD FLOOR SIMILAR

| | | |
|---|---|---|
| SCOTT HART BLD'G<br>SECOND & THIRD FLOORS<br>HELENA, MONTANA | DRAPES ENGINEERING<br>MECHANICAL & ELECTRICAL ENGINEERS<br>GREAT FALLS, MONTANA | DATE 12/27/78<br>SHEET<br>OF |


ALT.#6-INSULATE WALLS WITH 7" BEADBOARD INSULATION.
ALT.#7-BLOCK 80% OF WINDOW AREA WITH 7" OF BEADBOARD. INSTALL DOUBLE GLAZED UNITS IN REMAINING AREA.
ALT.#2-MODIFY VENTILATION CONTROLS.
ADDITION
N

# FOURTH FLOOR - SCOTT HART BUILDING

FIFTH FLOOR SIMILAR

| | | |
|---|---|---|
| SCOTT HART BUILDING<br>FOURTH & FIFTH FLOORS<br>HELENA, MONTANA | DRAPES ENGINEERING<br>MECHANICAL & ELECTRICAL ENGINEERS<br>GREAT FALLS, MONTANA | DATE 5-27-77<br>SHEET<br>OF |

TABLE 7.10

LIFE CYCLE COST SUMMARY

SCOTT HART BUILDING

| Alt. | Alternative Description | First Cost ($1000's) | Present Worth of Life Cycle Cost Savings ($1000's) | | Breakeven On First Cost (Yr) | | Percent Energy Savings | EUI BTU / GSF-DD |
|---|---|---|---|---|---|---|---|---|
| | | | Min. | Max. | Min. | Max. | | |
| 1 | Existing Building | - | - | - | - | - | - | 12.02 |
| 2 | Modify ventilation controls | 2.2 | 5.2 | 11 | 12 | 13 | .8 | 11.92 |
| 3 | Flue dampers | 3.3 | 18 | 34 | 7 | 8 | 2.3 | 11.74 |
| 4 | Insulate boilers | 1.0 | 14 | 25 | 4 | 4 | 1.6 | 11.83 |
| 5 | Insulate roof | 14 | 21 | 47 | 15 | 17 | 3.7 | 11.57 |
| 6 | Insulate walls | 120 | 11 | 106 | 25 | 33 | 13.9 | 10.35 |
| 7 | Block windows & double-glaze | 95 | 188 | 395 | 13 | 15 | 30.0 | 8.41 |

3. LIFE CYCLE CONSERVATION RECOMMENDATIONS

a. The following recommendations, in order of priority, are to conserve energy and reduce the Life Cycle owning and operating costs of the Scott Hart Building.

1. Alternative #4

Insulate the boilers with six inches of rigid fiberglass insulation. Estimated energy savings are 1.6% for an investment of $1,000.00 with a payback of four years.

2. Alternative #3

Install boiler flue dampers to reduce standby losses. Estimated energy savings are 2.3% for an investment of $3,300.00 with a payback of seven to eight years (minimum to maximum).

3. Alternative #2

Modify H&V units in the addition to minimize fresh air intake except when cooling is required. Estimated energy savings are 0.8% for an investment of $2,200.00 with a payback of 12 to 13 years.

4. Alternative #7

Block 80% of the window area with seven inches of beadboard and a stucco finish. Install openable double-glazed units in the remaining openings. Estimated energy savings are 30.0% for an investment of $95,000.00 with a payback of 13 to 15 years.

5. Alternative #5

Add five inches of beadboard insulation when the existing roof on the original building section is replaced. Estimated energy savings are 3.7% for an investment of $14,000.00 with a payback of 15 to 17 years.

3. LIFE CYCLE CONSERVATION RECOMMENDATIONS (CONT'D)

6. Alternative #6

Insulate the exterior walls of all building sections with seven inches of beadboard insulation and stucco finish. Estimated energy savings are 13.9% for an investment of $120,000.00 with a payback of 25 to 33 years.

1. BUILDING DESCRIPTION

a. General

Womack Armory at Fort Harrison, Montana, was built in 1970 with a total floor area of 21,820 square feet. Most of the area is on the first floor which contains classrooms and office space, supply areas, kitchen, lockers, assembly, rifle range, and mechanical space. The smaller area on the second floor is used for office space and a second mechanical room.

The kitchen area is not being used. The assembly and rifle range areas have only occasional use and are maintained at reduced temperatures, $45^{o}$-$50^{o}$, when not used during the heating season.

b. Building Envelope

The building has a built-up roof with three inches of fiberglass insulation on the underside. The only exception is over the vault area where the roof contains a six-inch concrete slab and two inches of rigid insulation. Walls are twelve-inch uninsulated block and eight-inch block with filled cores. Single-pane glass is used throughout the building.

c. Heating, Ventilation, and Air-Conditioning System

Heat for the building is primarily natural gas, through some of the rooms have electric heat. Direct-fired heating and ventilating units supply the assembly and rifle range. A multizone unit provides heating and ventilation for the north side of the building. Another multizone unit supplies the southeast portion of the first floor and second floor. Minimum outdoor air settings are 15% on all units.

2. LIFE CYCLE ENERGY ANALYSIS

a. Description of Alternatives

The following are energy conserving alternatives that were investigated for the Womack Armory.

Alternative #1

This alternative is the existing building "as is". Alternative #1 is the basis of comparison for the other alternatives.

Alternative #2

Add beadboard insulation when reroofing: five inches over assembly and rifle range and eight inches over the rest of the building.

Alternative #3

Add beadboard insulation to the inside of exterior walls with a finished gypsum board cover: nine inches around the assembly and rifle range and eleven inches around the rest of the building.

Alternative #4

Block and insulate 75% of the windows in the southeast corner with eleven inches of beadboard insulation finished to match wall insulation listed in Alternative #3.

Alternative #5

Add a second pane of glass to remaining inoperable windows.

Alternative #6

Install flue dampers on both multizone units and the direct-fired heating and ventilating units to reduce standby losses.

Alternative #7

Reset outdoor air dampers to 10% and apply weatherstripping around windows and overhead doors.

2. LIFE CYCLE ENERGY ANALYSIS (CONT'D)

Alternative #8

Add two-inch insulating metal panels to overhead doors.

Alternative #9

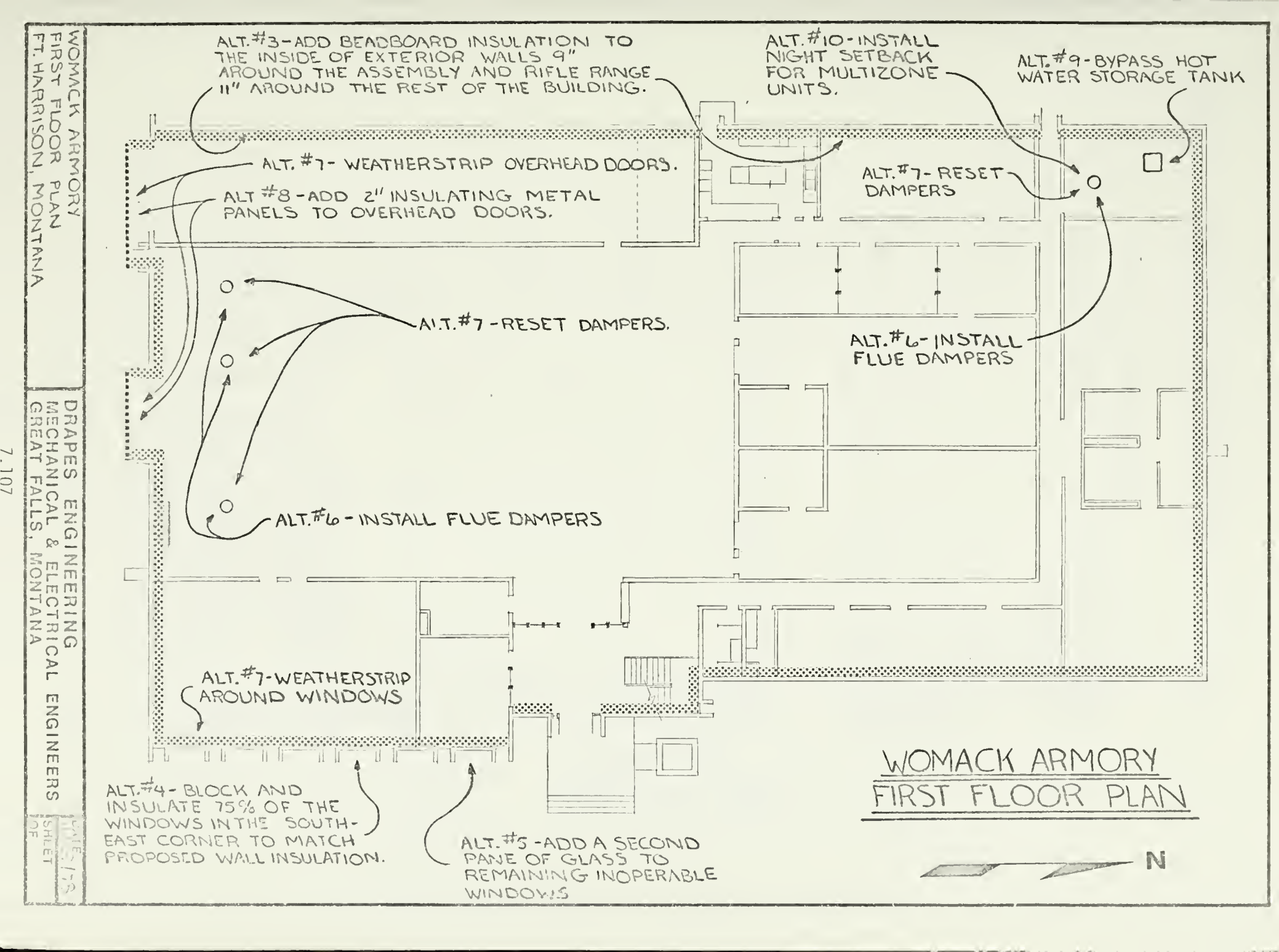
Bypass domestic hot water storage tank.

Alternative #10

Install night setback controls for the multizone units.

b. Life Cycle Cost Summary

Table 7.11 is a summary of the Life Cycle Cost Analysis of each alternative showing the estimated first cost, the present worth of life cycle cost savings, the breakeven point or payback of first cost in years, the percent energy savings, and the energy consumption in Btu/gross square foot of building area/degree day of each alternative.


WOMACK ARMORY
FIRST FLOOR PLAN
FT. HARRISON, MONTANA
DRAPES ENGINEERING
MECHANICAL & ELECTRICAL ENGINEERS
GREAT FALLS, MONTANA
DATE
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ALT.#3-ADD BEADBOARD INSULATION TO THE INSIDE OF EXTERIOR WALLS 9" AROUND THE ASSEMBLY AND RIFLE RANGE 11" AROUND THE REST OF THE BUILDING.
ALT.#10-INSTALL NIGHT SETBACK FOR MULTIZONE UNITS.
ALT.#9-BYPASS HOT WATER STORAGE TANK
ALT.#7-WEATHERSTRIP OVERHEAD DOORS.
ALT #8-ADD 2" INSULATING METAL PANELS TO OVERHEAD DOORS.
ALT.#7-RESET DAMPERS
ALT.#7-RESET DAMPERS.
ALT.#6-INSTALL FLUE DAMPERS
ALT.#6-INSTALL FLUE DAMPERS
ALT.#7-WEATHERSTRIP AROUND WINDOWS
ALT.#4-BLOCK AND INSULATE 75% OF THE WINDOWS IN THE SOUTH-EAST CORNER TO MATCH PROPOSED WALL INSULATION.
ALT.#5-ADD A SECOND PANE OF GLASS TO REMAINING INOPERABLE WINDOWS
WOMACK ARMORY
FIRST FLOOR PLAN
N

TABLE 7.11

LIFE CYCLE COST SUMMARY

WOMACK ARMORY

| Alt. | Alternative Description | First Cost ($1000's) | Present Worth of Life Cycle Cost Savings ($1000's) | | Breakeven On First Cost (Yr) | | Percent Energy Savings | EUI BTU/GSF-DD |
|---|---|---|---|---|---|---|---|---|
| | | | Min. | Max. | Min. | Max. | | |
| 1 | Existing Building | - | - | - | - | - | - | 14.64 |
| 2 | Insulate Roof | 32 | -.3 | 34 | 32 | >45 | 7.0 | 13.61 |
| 3 | Insulate Wall | 33 | 108 | 262 | 13 | 15 | 30.9 | 10.11 |
| 4 | Block and Insulate Windows | 1.4 | 19 | 42 | 5 | 5 | 4.6 | 13.96 |
| 5 | Double-Glaze | 2.3 | 2.4 | 7.7 | 21 | 27 | 1.1 | 14.48 |
| 6 | Flue Dampers | 2.3 | 10 | 24 | 11 | 12 | 2.8 | 14.23 |
| 7 | Weatherstrip | 1.1 | 50 | 105 | 2 | 2 | 11.4 | 12.97 |
| 8 | Insulate Garage Doors | 1.6 | 3.7 | 9.6 | 15 | 18 | 1.2 | 14.46 |
| 9 | Bypass Hot Water Storage | 0.3 | 3.5 | 7.7 | 5 | 5 | .8 | 14.52 |
| 10 | Night Setback | 1.7 | 32 | 68 | 4 | 4 | 7.5 | 13.54 |

3. LIFE CYCLE CONSERVATION RECOMMENDATIONS

a. The following recommendations, in order of priority, are to conserve energy and reduce the Life Cycle owning and operating costs of the Womack Armory.

1. Alternative #7

Reset outdoor air dampers to 10% and apply weatherstripping around windows and overhead doors. Estimated energy savings are 11.4% with a payback of two years for an investment of $1,154.00.

2. Alternative #10

Install night setback controls for the multizone units. Estimated energy savings are 7.5% with a payback of four years for an investment of $1,718.00.

3. Alternative #9

Bypass domestic hot water storage tank. Estimated energy savings are 0.8% with a payback of five years for an investment of $252.00.

4. Alternative #4

Block and insulate 75% of the windows in the southeast corner with eleven inches of beadboard insulation. Estimated energy savings are 4.6% with a payback of five years for an investment of $1,434.00.

5. Alternative #6

Install flue dampers. Estimated energy savings are 2.8% with a payback of 11 to 12 years for an investment of $2,291.00.

6. Alternative #3

Add nine or eleven inches of beadboard insulation to the inside of exterior walls. Estimated energy savings are 30.9% with a payback of 13 to 15 years for an investment of $33,052.00.

3. LIFE CYCLE CONSERVATION RECOMMENDATIONS (CONT'D)

7. Alternative #8

Add two-inch insulating metal panels to overhead doors. Estimated energy savings are 1.2% with a payback of 15 to 18 years for an investment of $1,573.00.

8. Alternative #5

Add a second pane of glass to inoperable windows that were not blocked by Alternative #4. Estimated energy savings are 1.1% with a payback of 21 to 27 years for an investment of $2,308.00.

9. Alternative #2

Add five or eight inches of beadboard insulation when reroofing. Estimated energy savings of 7.0% with a payback of 32 years to no payback for an investment of $31,584.00.

1. BUILDING DESCRIPTION

a. General

The NMC Married Student Apartments consist of five building groups with sub-buildings in each group except one. Two building groups were built in 1959-1960 with the remaining three building groups built in 1961.

The original two building groups, Building #1 and Building #2 are "T" shaped buildings. The part of the building forming the horizontal part of the "T" is a two-story building connected to the main building, the vertical part of the "T", with a breezeway. The main building is single-floor becoming a two-story structure at the top of the "T". Building #1 contains the mechanical room with boilers that supply heat to all five buildings. Buildings #1 and #2 each contain nine apartments.

Building Group #1A, is basically the same as #1 except that it consists of four distinct buildings, each connected with a breezeway. There are fourteen apartments in Building #1A.

Building #1B is a rectangular single building with four apartments.

Building #1C is the same as Building #1 except for dimensions and contains eleven apartments.

b. Building Envelope

Wall construction of each building consists of the same two types. The walls with window and door areas consist of wood frame walls with 1/2 inch siding, 1/2 inch sheathing, 3-1/2 inches of fiberglass batt insulation and an interior finish of 1/2 inch gypsum board. The walls where

1. BUILDING DESCRIPTION (CONT'D)

wall openings were minimal, consist of 8-inch CMU with zonolite-filled cores.

The roof is a pitched wood frame roof with 3/4 inch plywood decking overlayed with about two inches of rigid insulation. The exterior surface is a standard built-up roof. The interior finish is acoustical tile glued to the decking.

The windows are double-glazed wood framed windows in moderate condition.

c. Heating and Ventilation

Steam is supplied to units that are equipped with steam fan turbines that draw heat across a steam coil. Each apartment has five of these units which are individually controlled by an uncalibrated thermostat. Ventilation consists of fresh air from opening windows.

The steam is supplied by a boiler located in Building #1's mechanical room.

There is no university supplied air-conditioning.

2. LIFE CYCLE ENERGY ANALYSIS

a. Description of Alternatives

The following alternatives were investigated for achieving energy conservation.

Alternative #1

This alternative is the existing buildings "as is". Alternative #1 will be used as the basis for comparison against subsequent alternatives.

Alternative #2

Seal the three boiler and two incinerator barometric dampers. Three boiler dampers and one incinerator damper are in Building #1's mechanical room. The remaining incinerator damper is in Building #2. Sealing these dampers will minimize heat loss from the mechanical rooms by reducing unnecessary ventilation.

Alternative #3

Replace the existing steam coil and steam fan turbine heating system with steam heating electric fan coil units. Energy savings will result because of better temperature control and because of tenant initiated night setback capability. Also since the currently used units require excessive maintenance, a savings of maintenance costs will also be realized.

Alternative #4

Insulate the two operational boilers with an additional three inches of fiberglass insulation and insulate the domestic hot water storage tank with an additional five inches of fiberglass insulation.

2. LIFE CYCLE ENERGY ANALYSIS (CONT'D)

Alternative #5

Insulate the exterior side of the wood frame wall sections with six inches of glued-on beadboard insulation with an exterior finish of stucco.

Alternative #6

Insulate the exterior side of the eight-inch CMU walls with six inches of glued-on beadboard insulation with an exterior finish of stucco.

Alternative #7

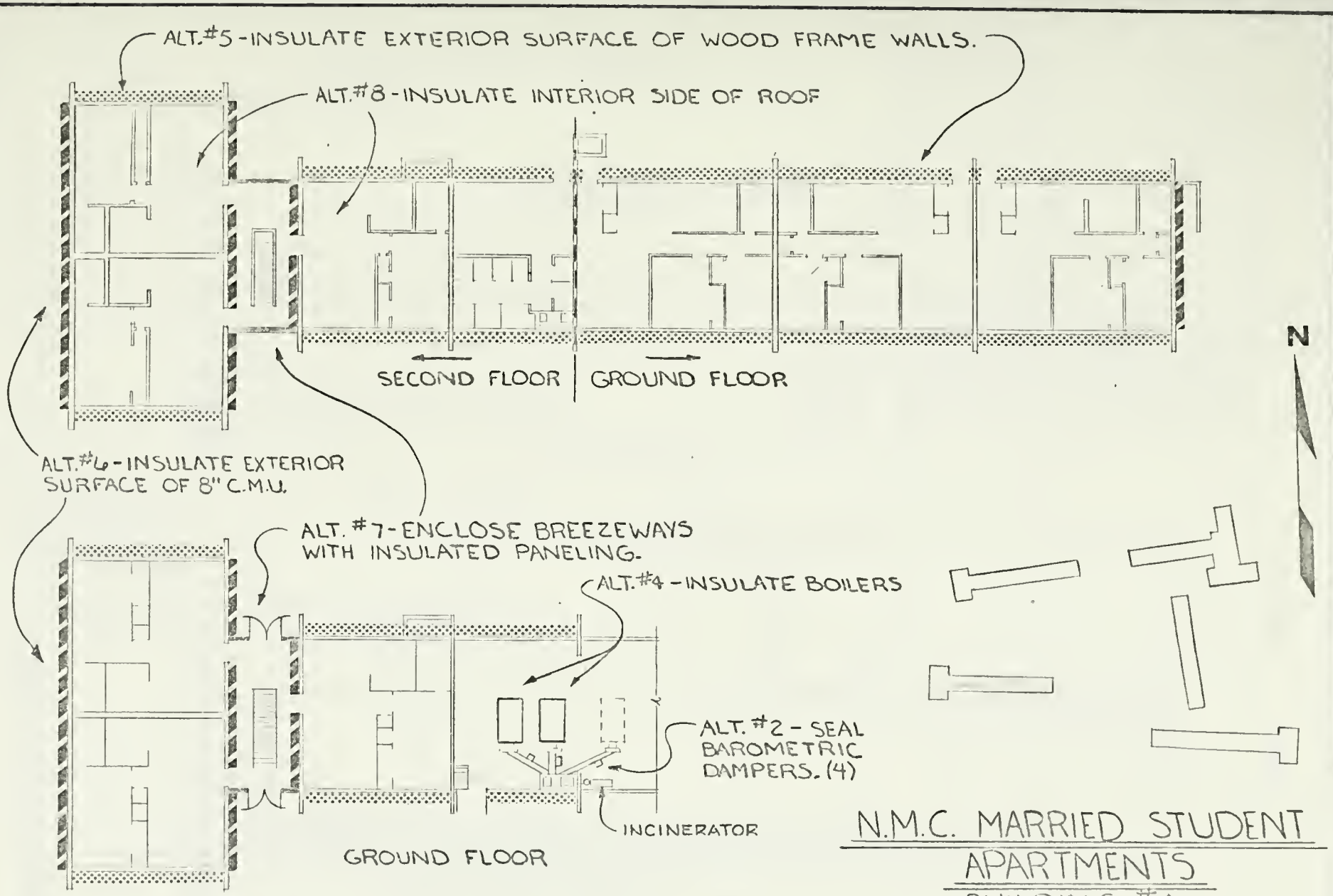
Enclose the breezeways of Buildings #1, #2, #1A and #1C with an insulating panel system and insulate breezeway roof with glued-on beadboard. This reduces the heat loss by reducing the heated surface area and by forming a quasi-type vestibule.

Alternative #8

Insulate the interior side of the roof with six inches of beadboard and cover with 5/8 inch painted sheetrock.

b. Life Cycle Cost Summary

Table 7.12 is a summary of the Life Cycle Cost Analysis of each alternative showing the estimated first cost, the present worth of life cycle cost savings, the breakeven point or payback of first cost in years, the percent energy savings, and the energy consumption in Btu/gross square foot of building area/degree day of each alternative.


ALT.#5 - INSULATE EXTERIOR SURFACE OF WOOD FRAME WALLS.
ALT.#8 - INSULATE INTERIOR SIDE OF ROOF
SECOND FLOOR
GROUND FLOOR
N
ALT.#6 - INSULATE EXTERIOR SURFACE OF 8" C.M.U.
ALT. #7 - ENCLOSE BREEZEWAYS WITH INSULATED PANELING.
ALT.#4 - INSULATE BOILERS
ALT. #2 - SEAL BAROMETRIC DAMPERS. (4)
INCINERATOR
GROUND FLOOR

# N.M.C. MARRIED STUDENT APARTMENTS
## BUILDING #1

NORTHERN MONTANA COLLEGE
MARRIED STUDENTS APTS. BLD'G. 1
HAVRE, MONTANA

DRAPES ENGINEERING
MECHANICAL & ELECTRICAL ENGINEERS
GREAT FALLS, MONTANA

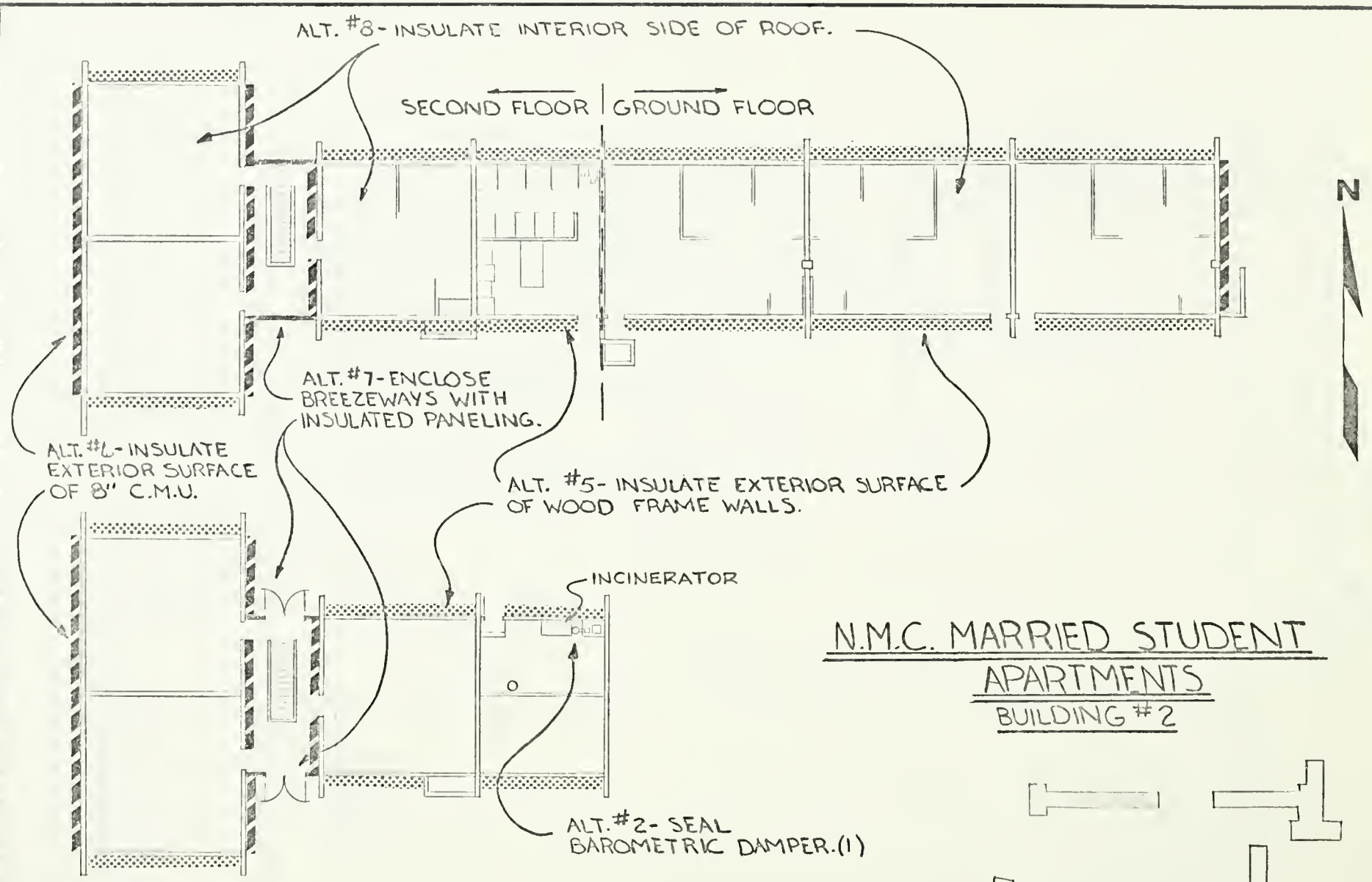
DATE 1/22/72
SHEET
OF

7.115

NORTHERN MONTANA COLLEGE
MARRIED STUDENTS APTS. BLD'G. 2
HAVRE, MONTANA

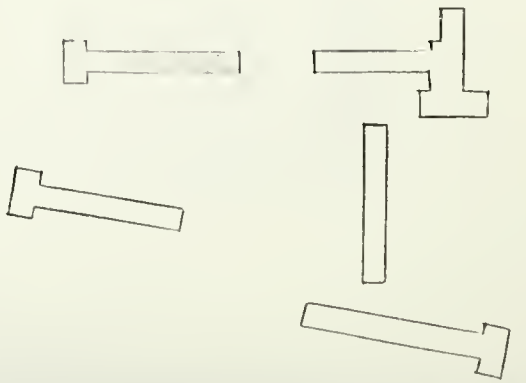
DRAPES ENGINEERING
MECHANICAL & ELECTRICAL ENGINEERS
GREAT FALLS, MONTANA

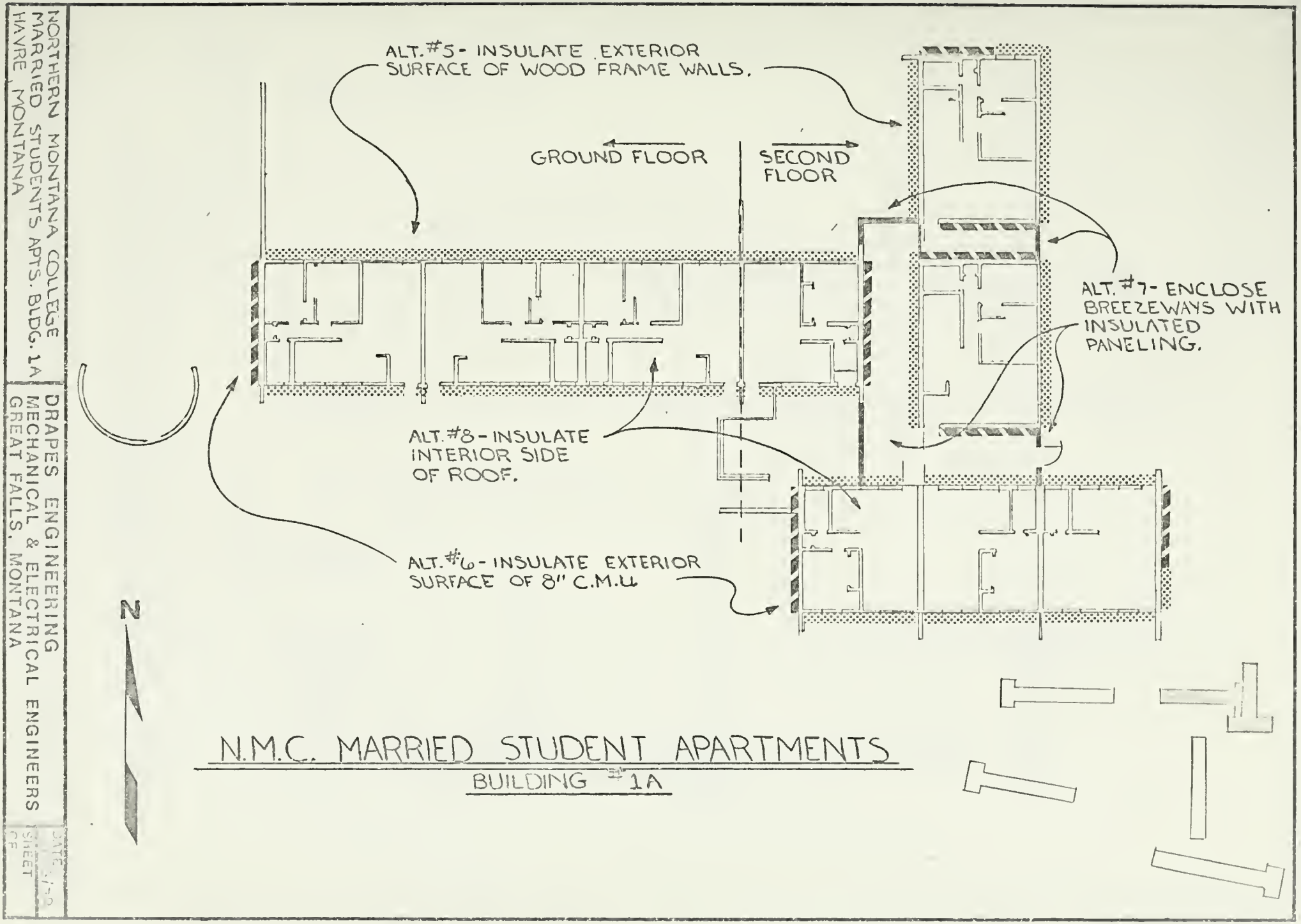
DATE 6/15
SHEET
OF


ALT. #8 - INSULATE INTERIOR SIDE OF ROOF.
SECOND FLOOR
GROUND FLOOR
N
ALT. #7 - ENCLOSE BREEZEWAYS WITH INSULATED PANELING.
ALT. #6 - INSULATE EXTERIOR SURFACE OF 8" C.M.U.
ALT. #5 - INSULATE EXTERIOR SURFACE OF WOOD FRAME WALLS.
INCINERATOR
ALT. #2 - SEAL BAROMETRIC DAMPER. (1)
GROUND FLOOR

# N.M.C. MARRIED STUDENT APARTMENTS

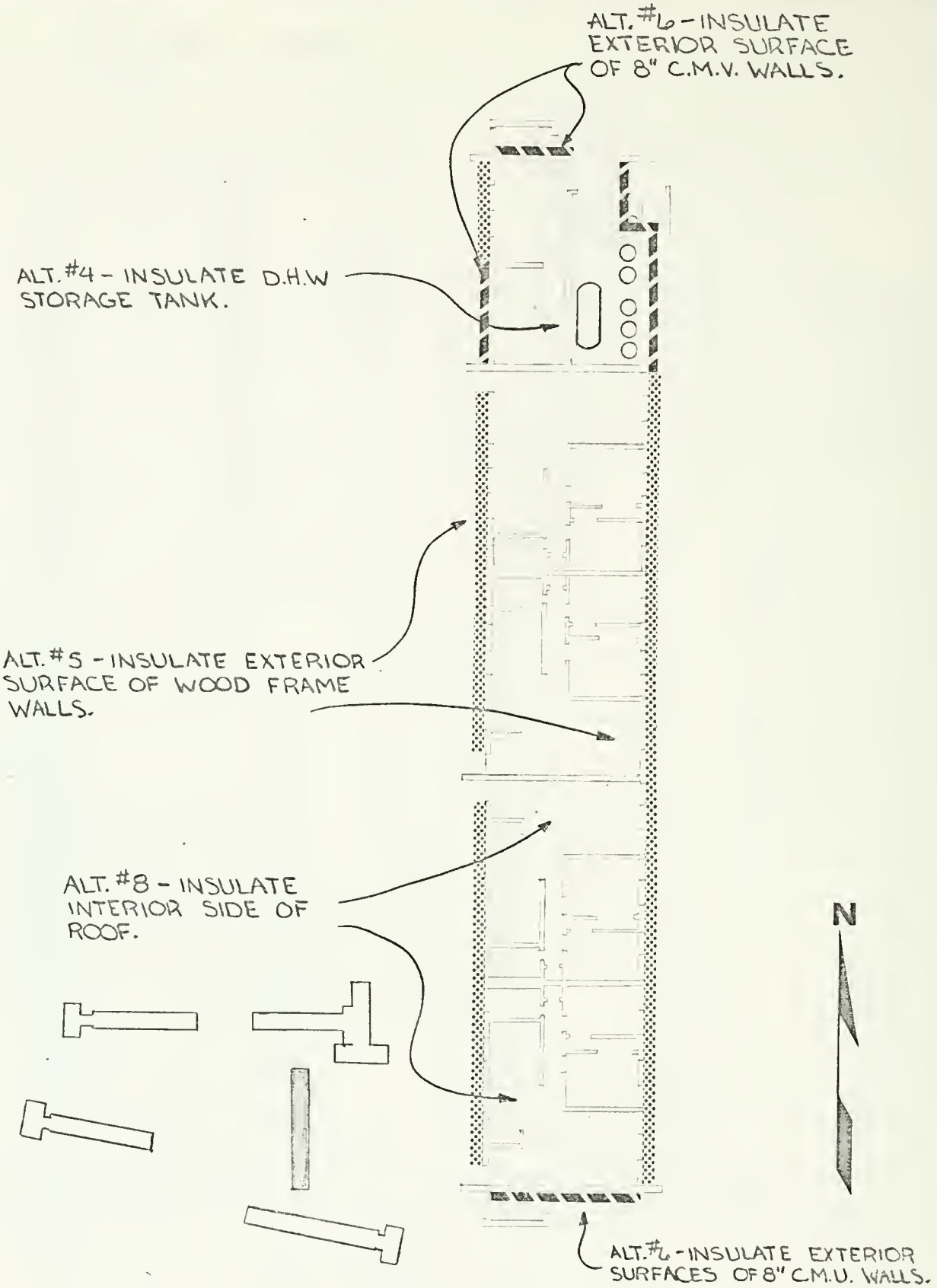
## BUILDING #2






# N.M.C. MARRIED STUDENT APARTMENTS

## BUILDING #1A


ALT. #6 - INSULATE EXTERIOR SURFACE OF 8" C.M.V. WALLS.
ALT. #4 - INSULATE D.H.W STORAGE TANK.
ALT. #5 - INSULATE EXTERIOR SURFACE OF WOOD FRAME WALLS.
ALT. #8 - INSULATE INTERIOR SIDE OF ROOF.
N
ALT. #6 - INSULATE EXTERIOR SURFACES OF 8" C.M.U. WALLS.

# N.M.C. MARRIED STUDENT APARTMENTS

## BUILDING 18

| | | |
|---|---|---|
| NORTHERN MONTANA COLLEGE<br>MARRIED STUDENTS APTS. BLD'G. 18<br>HAVRE MONTANA | DRAPES ENGINEERING<br>MECHANICAL & ELECTRICAL ENGINEERS<br>GREAT FALLS, MONTANA | DATE 11/13/72<br>SHEET<br>OF |

NORTHERN MONTANA COLLEGE
MARRIED STUDENT APTS. BLDG.1A
HAVRE, MONTANA

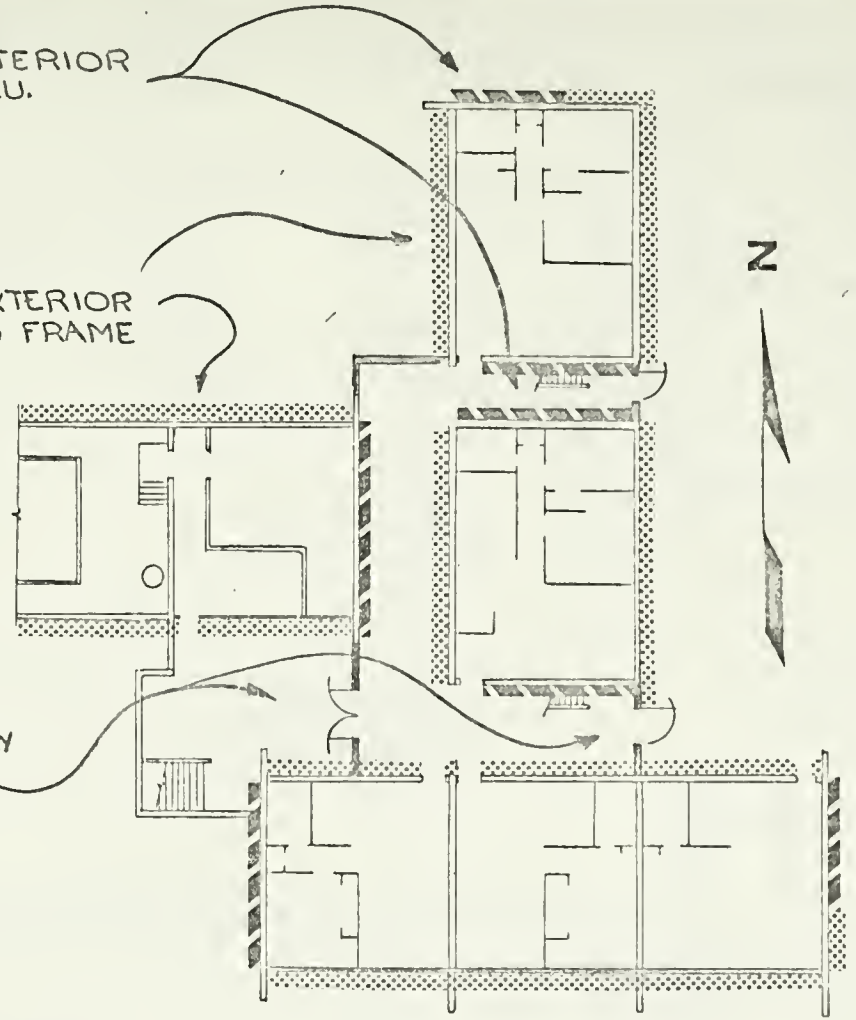
DRAPES ENGINEERING
MECHANICAL & ELECTRICAL ENGINEERS
GREAT FALLS, MONTANA

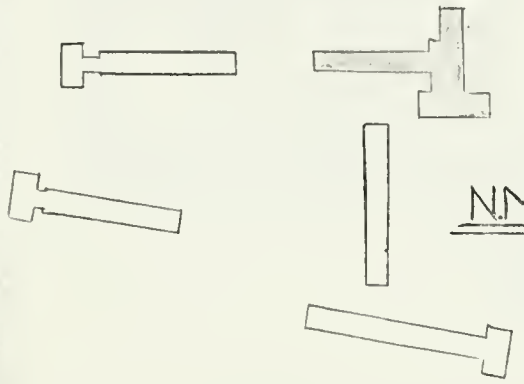
DATE 1-71
SHEET
OF

ALT.#6 - INSULATE EXTERIOR SURFACE OF 8" C.M.U.

ALT.#5 - INSULATE EXTERIOR SURFACE OF WOOD FRAME WALL.

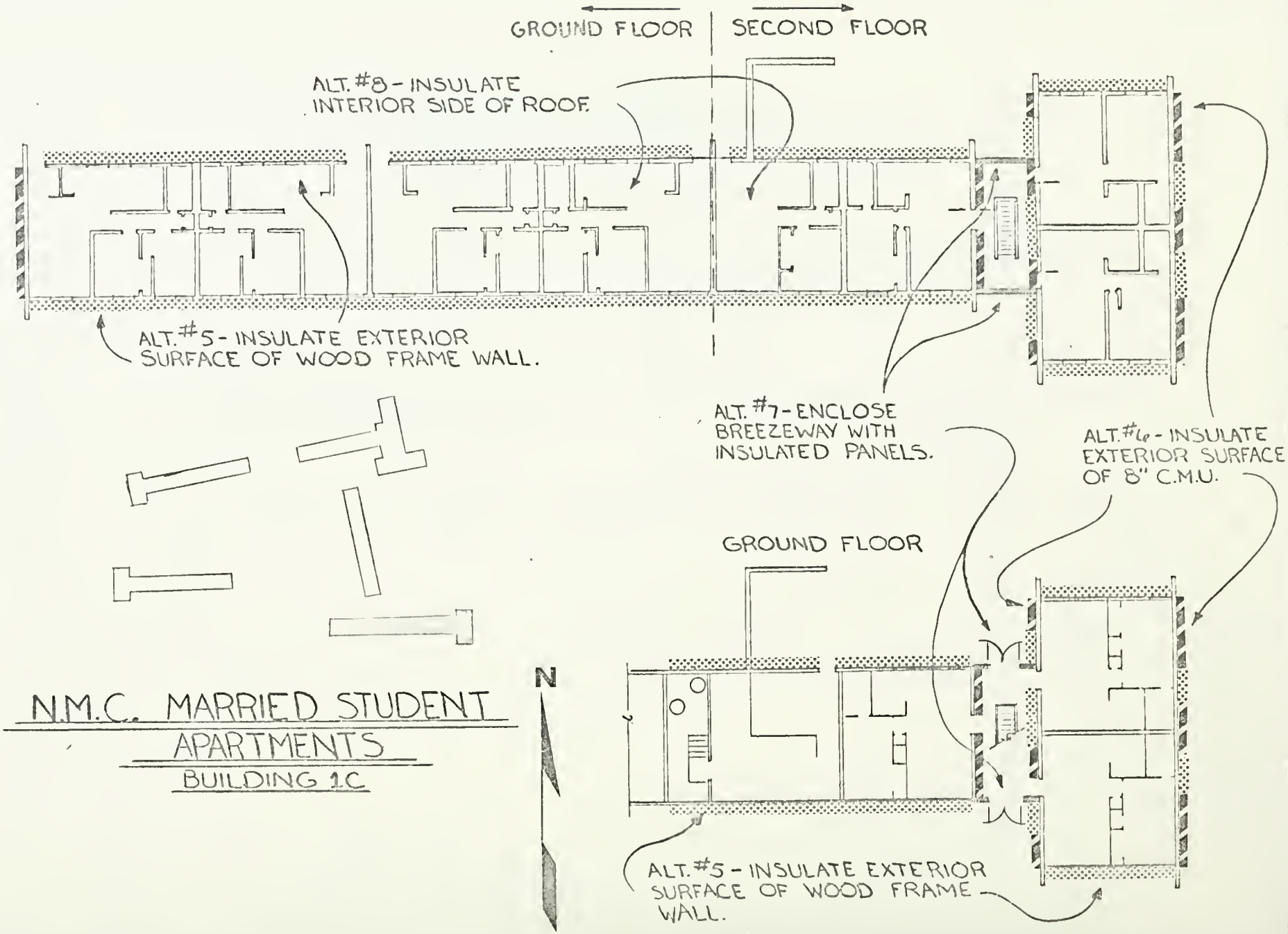
ALT.#7 - ENCLOSE BREEZEWAY WITH INSULATED PANELS.



# N.M.C. MARRIED STUDENT APARTMENTS

## GROUND FLOOR BUILDING 1A


GROUND FLOOR
SECOND FLOOR
ALT. #8 - INSULATE INTERIOR SIDE OF ROOF.
ALT. #5 - INSULATE EXTERIOR SURFACE OF WOOD FRAME WALL.
ALT. #7 - ENCLOSE BREEZEWAY WITH INSULATED PANELS.
ALT. #6 - INSULATE EXTERIOR SURFACE OF 8" C.M.U.
GROUND FLOOR
N
ALT. #5 - INSULATE EXTERIOR SURFACE OF WOOD FRAME WALL.

# N.M.C. MARRIED STUDENT APARTMENTS

## BUILDING 1C

NORTHERN MONTANA COLLEGE
MARRIED STUDENT APTS. BLDG. 1C
HAVRE, MONTANA

DRAPES ENGINEERING
MECHANICAL & ELECTRICAL ENGINEERS
GREAT FALLS, MONTANA

DATE
SHEET
OF

7.120

TABLE 7.12

LIFE CYCLE COST SUMMARY

NMC MARRIED STUDENT APARTMENTS

| Alt. | Alternative Description | First Cost ($1000's) | Present Worth of Life Cycle Cost Savings ($1000's) | | Breakeven On First Cost (Yr) | | Percent Energy Savings | EUI BTU/GSF-DD |
|---|---|---|---|---|---|---|---|---|
| | | | Min. | Max. | Min. | Max. | | |
| 1 | Existing Building | - | - | - | - | - | - | 19.13 |
| 2 | Seal Barometric Dampers | .2 | 2.6 | 5.0 | 4 | 4 | .3 | 19.07 |
| 3 | Install New Heating System | 146 | 61 | 57 | 28 | 28 | 2.7 | 18.62 |
| 4 | Insulate Boilers and DHW Tanks | 1.4 | 28 | 55 | 3 | 3 | 3.4 | 18.49 |
| 5 | Insulate Wood-Frames Wall Areas | 62 | -20 | 18 | 36 | >40 | 4.8 | 18.22 |
| 6 | Insulate 8-inch CMU Wall Areas | 28 | 18 | 58 | 22 | 28 | 5.1 | 18.15 |
| 7 | Enclose Breezeways With Insulated Walls | 27 | 40 | 99 | 17 | 20 | 7.5 | 17.69 |
| 8 | Insulate Interior Side of Roof | 49 | 65 | 167 | 18 | 21 | 12.8 | 16.68 |

3. LIFE CYCLE CONSERVATION RECOMMENDATIONS

a. The following recommendations, in order of priority, are to conserve energy and reduce the Life Cycle owning and operating of the NMC Married Student Apartments.

1. Alternative #4

Insulate the two operational boilers and the DHW storage tank. This provides an estimated energy savings of 3.4% for an investment of $1,430.00 with a payback of three years.

2. Alternative #2

Seal the three boiler and two incinerator barometric dampers. This provides an estimated energy savings of .3% for an investment of $170.00 with a payback of four years.

3. Alternative #7

Enclose the breezeways of Buildings #1, #2, #1A and #1C with an insulating panel system and insulate breezeway roof with glued-on beadboard. This provides an estimated energy savings of 7.5% for an investment of $26,900.00 with a payback of 17 to 20 years (minimum to maximum).

4. Alternative #8

Insulate the interior side of the roof with six inches of beadboard and cover with 5/8-inch painted sheetrock. This provides an estimated energy savings of 12.8% for an investment of $48,600.00 with a payback of 18 to 21 years.

5. Alternative #3

Replace existing steam coil and steam fan turbine heating system with steam heating electric fan coil units. This provides an esti-

3. LIFE CYCLE CONSERVATION RECOMMENDATIONS (CONT'D)

5. Alternative #3 (Cont'd)

estimated energy savings of 2.7% for an investment of $145,700.00 with a payback of 28 years.

6. Alternative #6

Insulate the exterior side of the eight-inch CMU walls with six inches of glued-on beadboard insulation with an exterior finish of stucco. This provides an estimated energy savings of 5.1% for an investment of $27,800.00 with a payback of 22 to 28 years.

7. Alternative #5

Insulate the exterior side of the wood frame wall sections with six inches of glued-on beadboard insulation with an exterior finish of stucco. This provides an estimated energy savings of 4.8% for an investment of $61,800.00 with a payback of 36 years to a time greater than the estimated building life of 40 years.

1. BUILDING DESCRIPTION

a. General

Morgan Hall has been built in three stages. The original building, built in 1956 consists of a three-story rectangular living area (Unit A) connected to a single-story with a partial basement rectangular food service and recreation building (Unit B). The food service equipment of Unit B has since been dismantled and removed. Over the recreation area of Unit B, the roof has been elevated to form a clear story with glass walls.

The first addition (Unit C) consists of a living area wing connected on the opposing side of Unit B from Unit A. Unit C has only two floors.

The second addition (Unit D) consists of a living area wing connected to Unit B between Units A and C. Unit D has three floors.

b. Building Envelope

All four sub-buildings are of the same general construction: wall areas with numerous openings and windows consist of an outer finish of colorbestos and an interior finish of painted wallboard with 3.5 inches of fiberglass insulation; the remaining walls, primarily short length walls, are 8-inch CMU with fill insulation. Walls with colorbestos exterior finish on Units A, C, and D, also have an exposed concrete beam that runs the length of the buildings. The beam is insulated on the interior with one inch of beadboard insulation.

1. BUILDING DESCRIPTION (CONT'D)

The roof of Units A, C, and D consist of a 4" wood deck with one inch of rigid insulation and sealed with a built-up roof. Interconnecting lobbies' roof consist of one-inch acoustical tile, 3.5 inches of batt insulation, a one-inch sheathing deck and sealed with a built-up roof. Unit B's main roof is similar to the lobbies' roofs'. The clear story roof is acoustical tile, 2.5 inches of T&G decking, two inches of rigid insulation and sealed with a built-up roofing.

The windows in Units A, C, and D have deteriorated to a condition that is very poor due to design. The windows are single-glazed, lack weather-stripping and are poor fitting. Weatherstripping is impractical due to window design.

c. Heating and Ventilation

Heating is accomplished with perimeter hot water in fin tube in Units A, C, and D. Unit B is heated with a combination of steam or hot water fin tube, fan coil units and convectors. Steam is supplied by two boilers which also heat the hot water for Units A, C, and D through a heat exchanger.

Ventilation is accomplished in all Units by operable window vents.

At this time there is no air-conditioned space.

2. LIFE CYCLE ENERGY ANALYSIS

a. Description of Alternatives

The following alternatives were investigated for achieving energy conservation.

Alternative #1

This alternative is the existing building "as is". Alternative #1 will be used as the basis for comparison against subsequent alternatives.

Alternative #2

Install night setback system to control temperature of the water for the hot water fin tube.

Alternative #3

Valve off on DHW storage tank and install separate gas water heater for summer usage.

Alternative #4

Insulate boilers and DHW storage tanks with an additional six inches of fiberglass insulation.

Alternative #5

Insulate the exterior surface of the wood framed and concrete beam exterior walls with six inches of glued-on beadboard covered with a finish of stucco.

Alternative #6

Insulate the exterior surface of the concrete block exterior walls with six inches of glued-on beadboard covered with a finish of stucco.

2. LIFE CYCLE ENERGY ANALYSIS (CONT'D)

Alternative #7

Insulate the exterior surface of the roof of Unit B and the associated lobbies with four inches of glued-on beadboard and insulate the exterior surface of the roofs of Units A, C, and D with six inches of glued-on beadboard. (Note: This alternative is to be done when the existing roof is replaced.)

Alternative #8

Replace existing glass windows in Units A, C, and D with a 50% smaller size double-glazed unit that is completely ventable. Block and insulate the remaining 50% area to match existing finish construction. In Unit B block and insulate to match existing surface finish all glass in the clear story, and Rooms 102, 103, 106, and 111. Block and insulate to match the existing surface finish 50% of the remaining glass in Unit B: in the remaining open area install double-glazed window units. In interconnecting lobbies, block and insulate to match existing surface finish all of the glass area.

b. Life Cycle Cost Summary

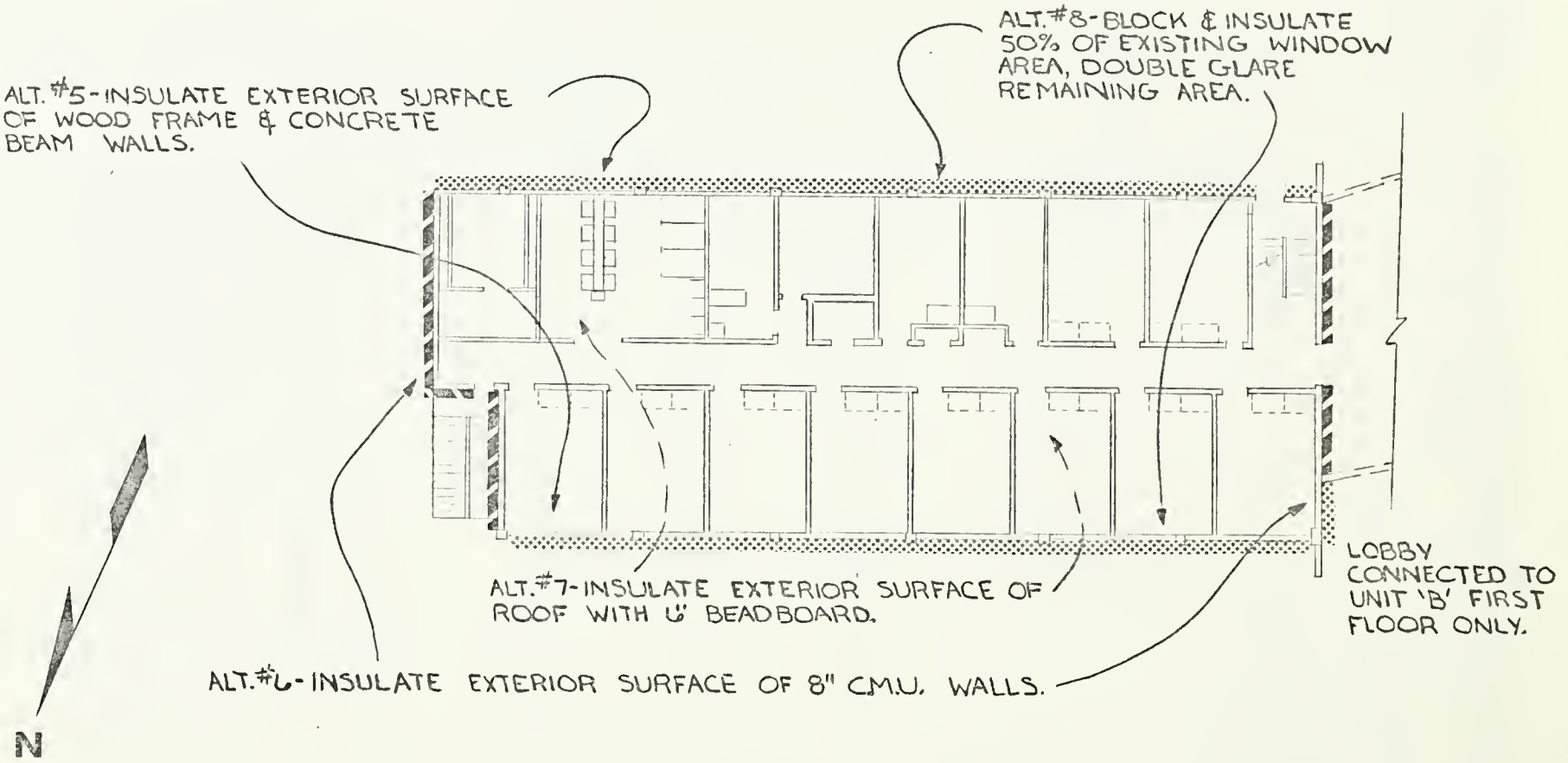
Table 7.13 is a summary of the Life Cycle Cost Analysis of each alternative showing the estimated first cost, the present worth of life cycle cost savings, the breakeven point or payback of first cost in years, the percent energy savings, and the energy consumption in Btu/gross square foot of building area/degree day of each alternative.

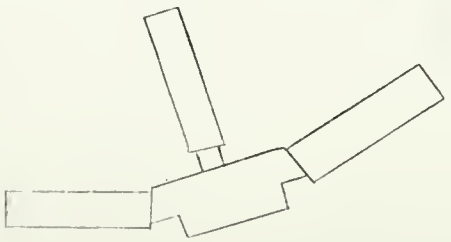
NORTHERN MONTANA COLLEGE
MORGAN HALL
HAVRE, MONTANA

DRAPES ENGINEERING
MECHANICAL & ELECTRICAL ENGINEERS
GREAT FALLS, MONTANA

DATE

SHEET
OF


ALT.#5-INSULATE EXTERIOR SURFACE OF WOOD FRAME & CONCRETE BEAM WALLS.
ALT.#8-BLOCK & INSULATE 50% OF EXISTING WINDOW AREA, DOUBLE GLARE REMAINING AREA.
ALT.#7-INSULATE EXTERIOR SURFACE OF ROOF WITH ½" BEADBOARD.
ALT.#6-INSULATE EXTERIOR SURFACE OF 8" C.M.U. WALLS.
LOBBY CONNECTED TO UNIT 'B' FIRST FLOOR ONLY.
N



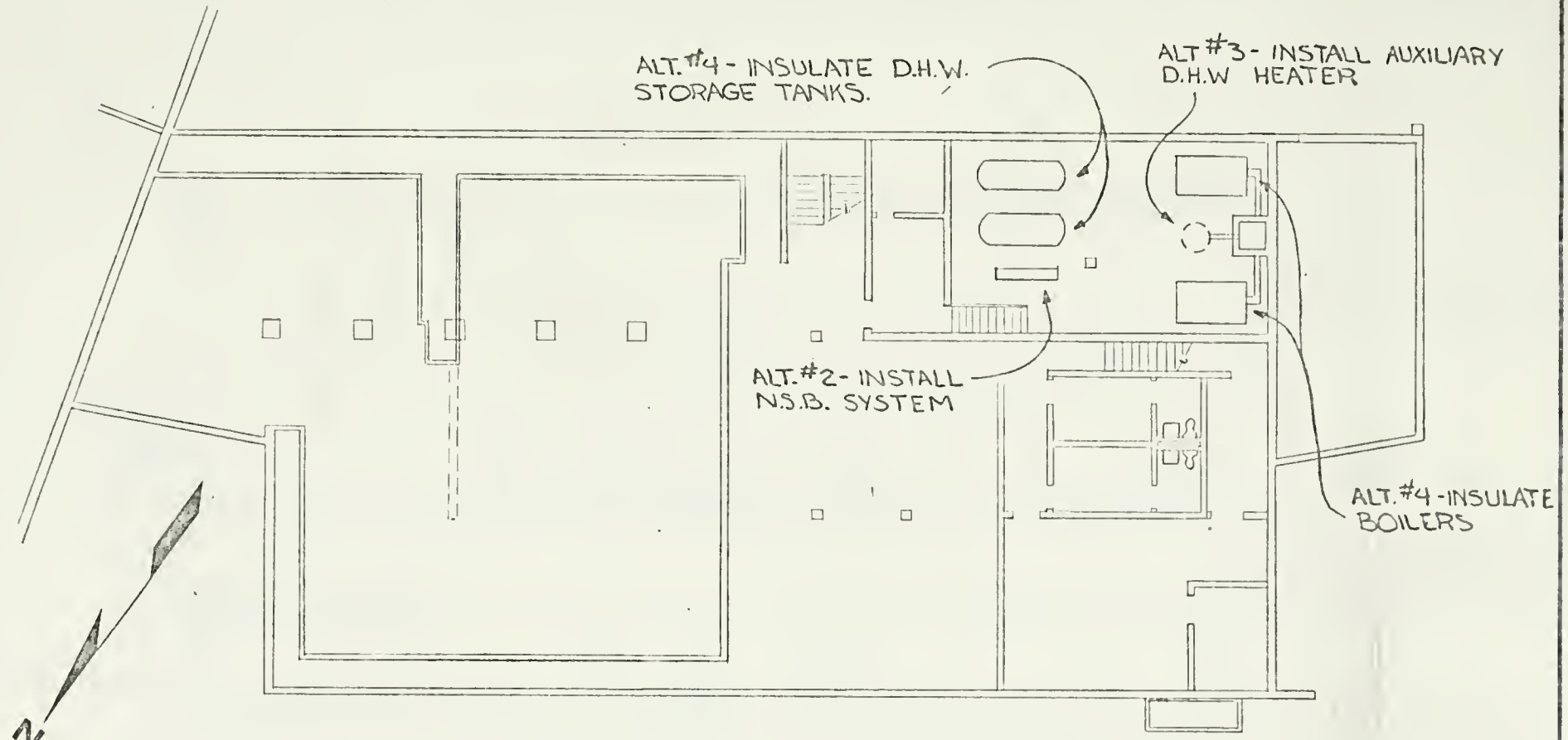
# N.M.C. MORGAN HALL - UNIT A
## FIRST FLOOR - MENS RESIDENCE
## SECOND & THIRD FLOORS SIMILAR

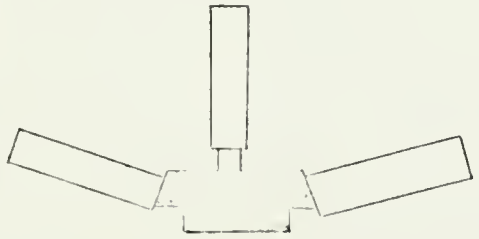
7.128

NORTHERN MONTANA COLLEGE
MEN'S DORMITORY
HAVRE, MONTANA

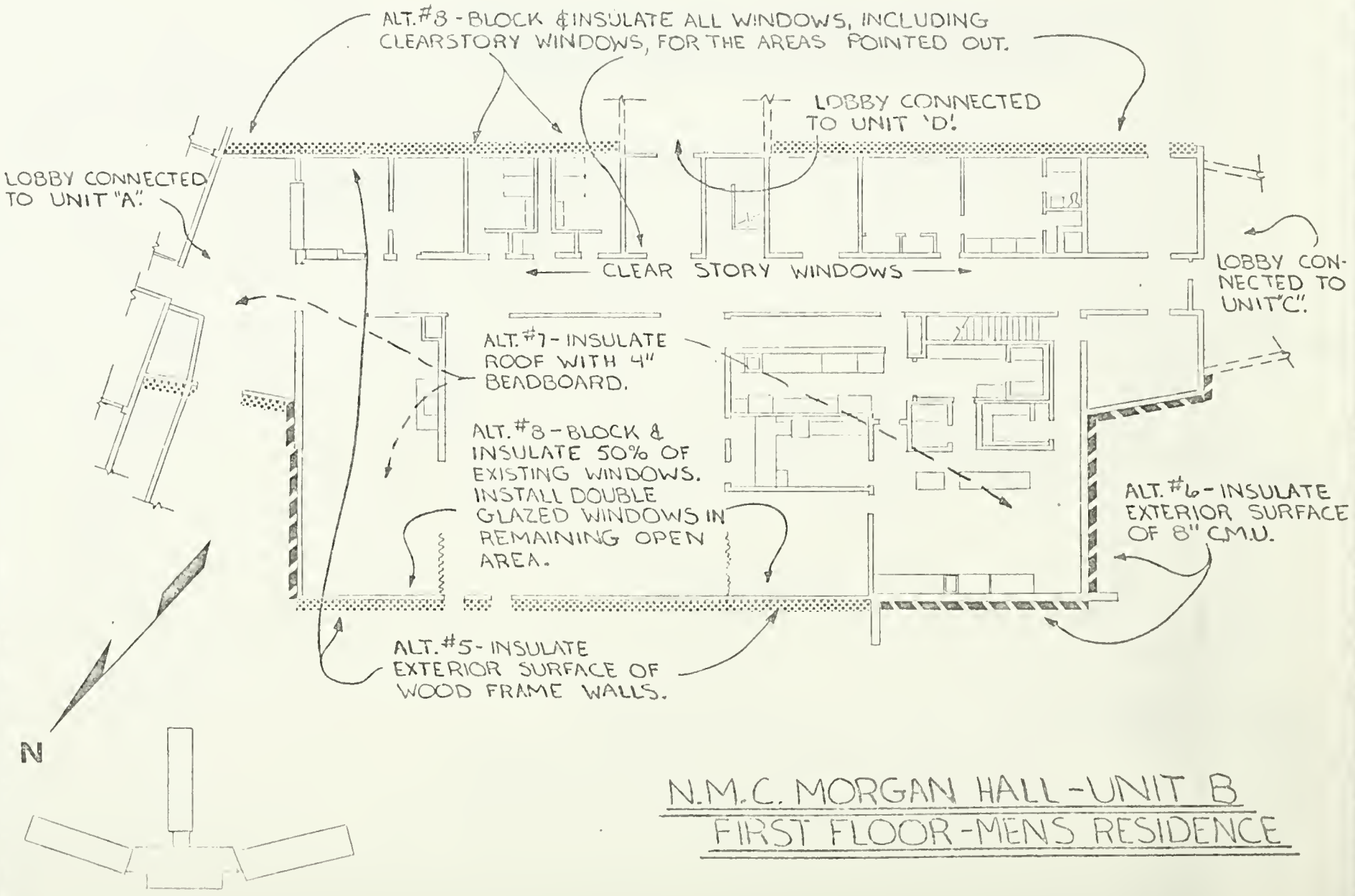
DRAPES ENGINEERING
MECHANICAL & ELECTRICAL ENGINEERS
GREAT FALLS, MONTANA

DATE 12-1-75
SHEET
OF



# N.M.C. MORGAN HALL - UNIT B
## BASEMENT FLOOR - MENS RESIDENCE

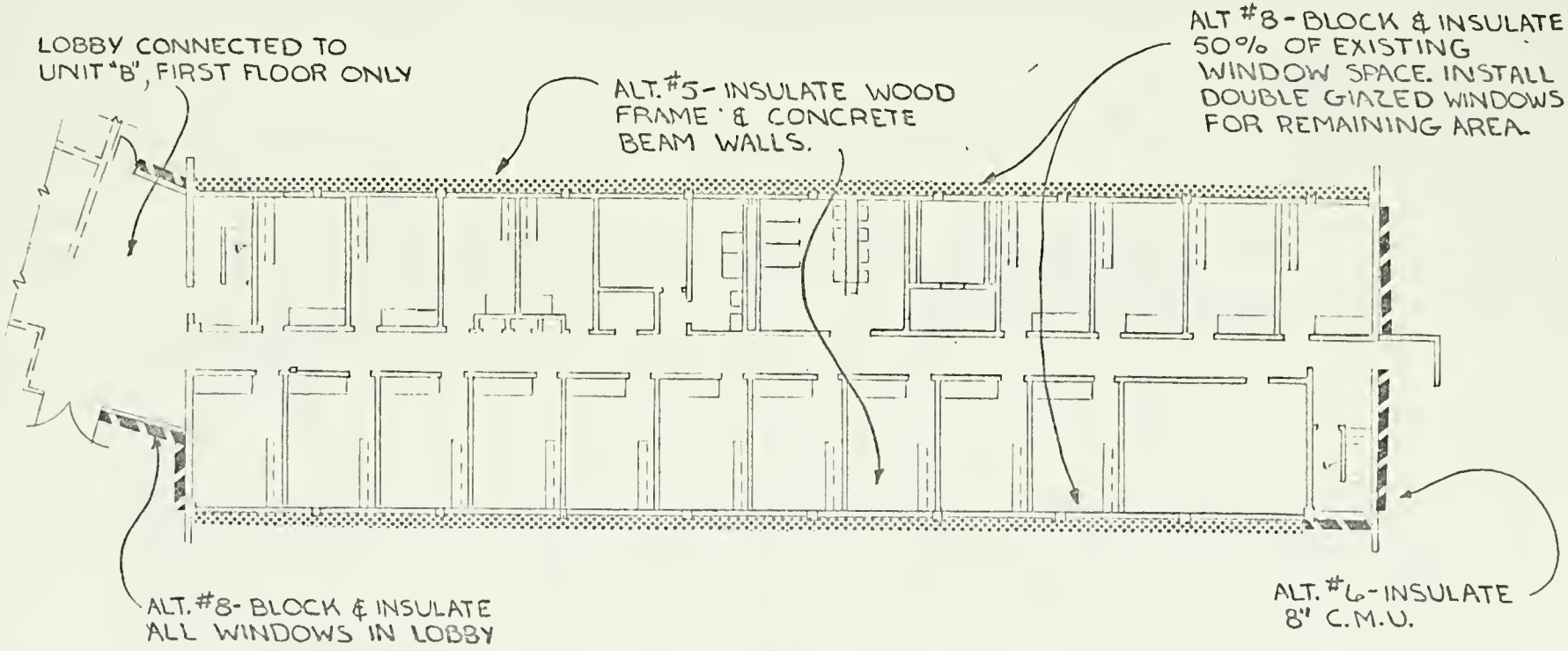

ALT.#8 - BLOCK & INSULATE ALL WINDOWS, INCLUDING CLEARSTORY WINDOWS, FOR THE AREAS POINTED OUT.
LOBBY CONNECTED TO UNIT 'D'.
LOBBY CONNECTED TO UNIT "A".
CLEAR STORY WINDOWS
LOBBY CONNECTED TO UNIT "C".
ALT.#7 - INSULATE ROOF WITH 4" BEADBOARD.
ALT.#8 - BLOCK & INSULATE 50% OF EXISTING WINDOWS. INSTALL DOUBLE GLAZED WINDOWS IN REMAINING OPEN AREA.
ALT.#6 - INSULATE EXTERIOR SURFACE OF 8" C.M.U.
ALT.#5 - INSULATE EXTERIOR SURFACE OF WOOD FRAME WALLS.
N

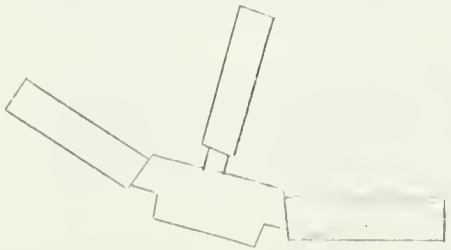
# N.M.C. MORGAN HALL - UNIT B
## FIRST FLOOR - MENS RESIDENCE

NORTHERN MONTANA COLLEGE
UNIT 'B' MEN'S DORM.
HAVRE, MONTANA

DRAPES ENGINEERING
MECHANICAL & ELECTRICAL ENGINEERS
GREAT FALLS, MONTANA

DATE 10-1-73
SHEET OF


LOBBY CONNECTED TO UNIT "B", FIRST FLOOR ONLY
ALT. #5 - INSULATE WOOD FRAME & CONCRETE BEAM WALLS.
ALT #8 - BLOCK & INSULATE 50% OF EXISTING WINDOW SPACE. INSTALL DOUBLE GLAZED WINDOWS FOR REMAINING AREA.
ALT. #8 - BLOCK & INSULATE ALL WINDOWS IN LOBBY
ALT. #6 - INSULATE 8" C.M.U.



N

# N.M.C. MORGAN HALL - UNIT C
## FIRST FLOOR - MENS RESIDENCE

NORTHERN MONTANA COLLEGE
UNIT "C" MENS DORM
HAVRE, MONTANA

DRAPES ENGINEERING
MECHANICAL & ELECTRICAL ENGINEERS
GREAT FALLS, MONTANA

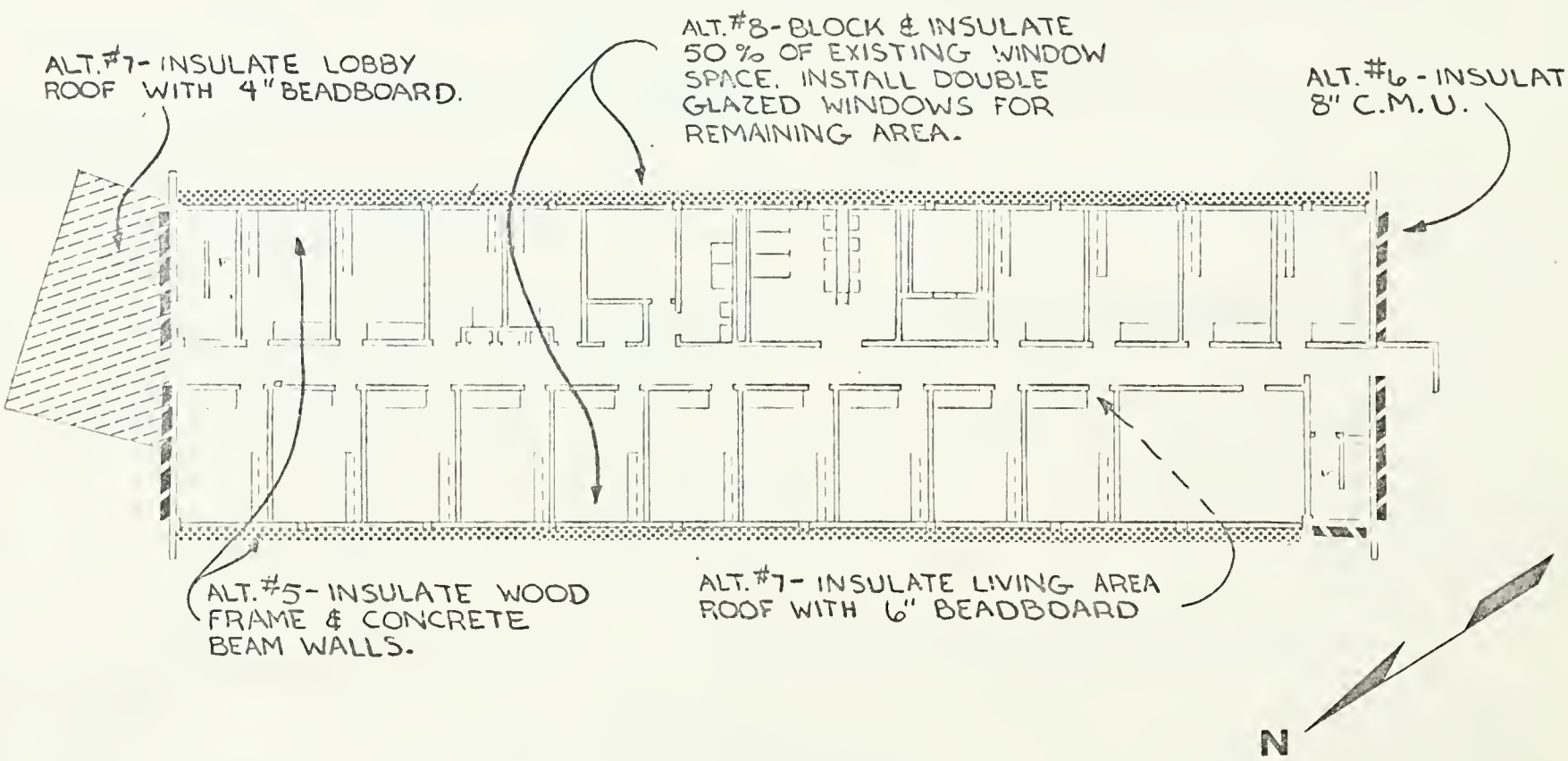
DATE
SHEET

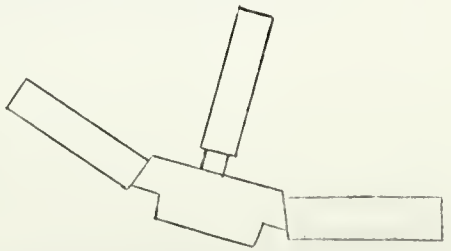
7.131

NORTHERN MONTANA COLLEGE
ADD'N TO MENS DORMITORY
HAVRE, MONTANA

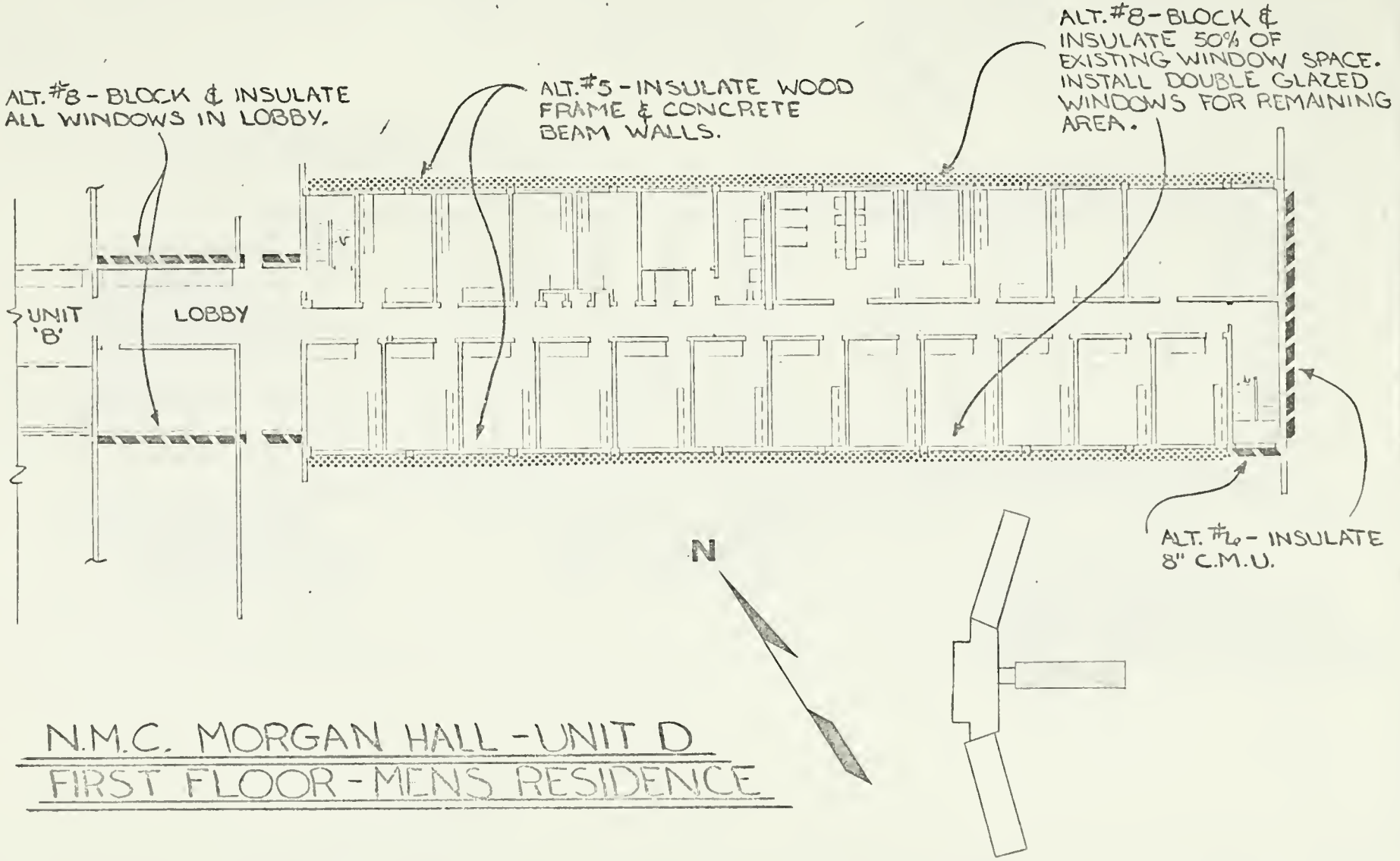
DRAPES ENGINEERING
MECHANICAL & ELECTRICAL ENGINEERS
GREAT FALLS, MONTANA

DATE 4-11-78
SHEET
OF


ALT.#7- INSULATE LOBBY ROOF WITH 4" BEADBOARD.
ALT.#8- BLOCK & INSULATE 50 % OF EXISTING WINDOW SPACE. INSTALL DOUBLE GLAZED WINDOWS FOR REMAINING AREA.
ALT.#6 - INSULATE 8" C.M.U.
ALT.#5- INSULATE WOOD FRAME & CONCRETE BEAM WALLS.
ALT.#7- INSULATE LIVING AREA ROOF WITH 6" BEADBOARD
N



# N.M.C. MORGAN HALL - UNIT C
# SECOND FLOOR - MENS RESIDENCE


ALT. #8 - BLOCK & INSULATE ALL WINDOWS IN LOBBY.
ALT. #5 - INSULATE WOOD FRAME & CONCRETE BEAM WALLS.
ALT. #8 - BLOCK & INSULATE 50% OF EXISTING WINDOW SPACE. INSTALL DOUBLE GLAZED WINDOWS FOR REMAINING AREA.
UNIT 'B'
LOBBY
ALT. #6 - INSULATE 8" C.M.U.
N

# N.M.C. MORGAN HALL - UNIT D
## FIRST FLOOR - MENS RESIDENCE

NORTHERN MONTANA COLLEGE
ADD'N UNIT 'D' MENS DORMS
HAVRE, MONTANA

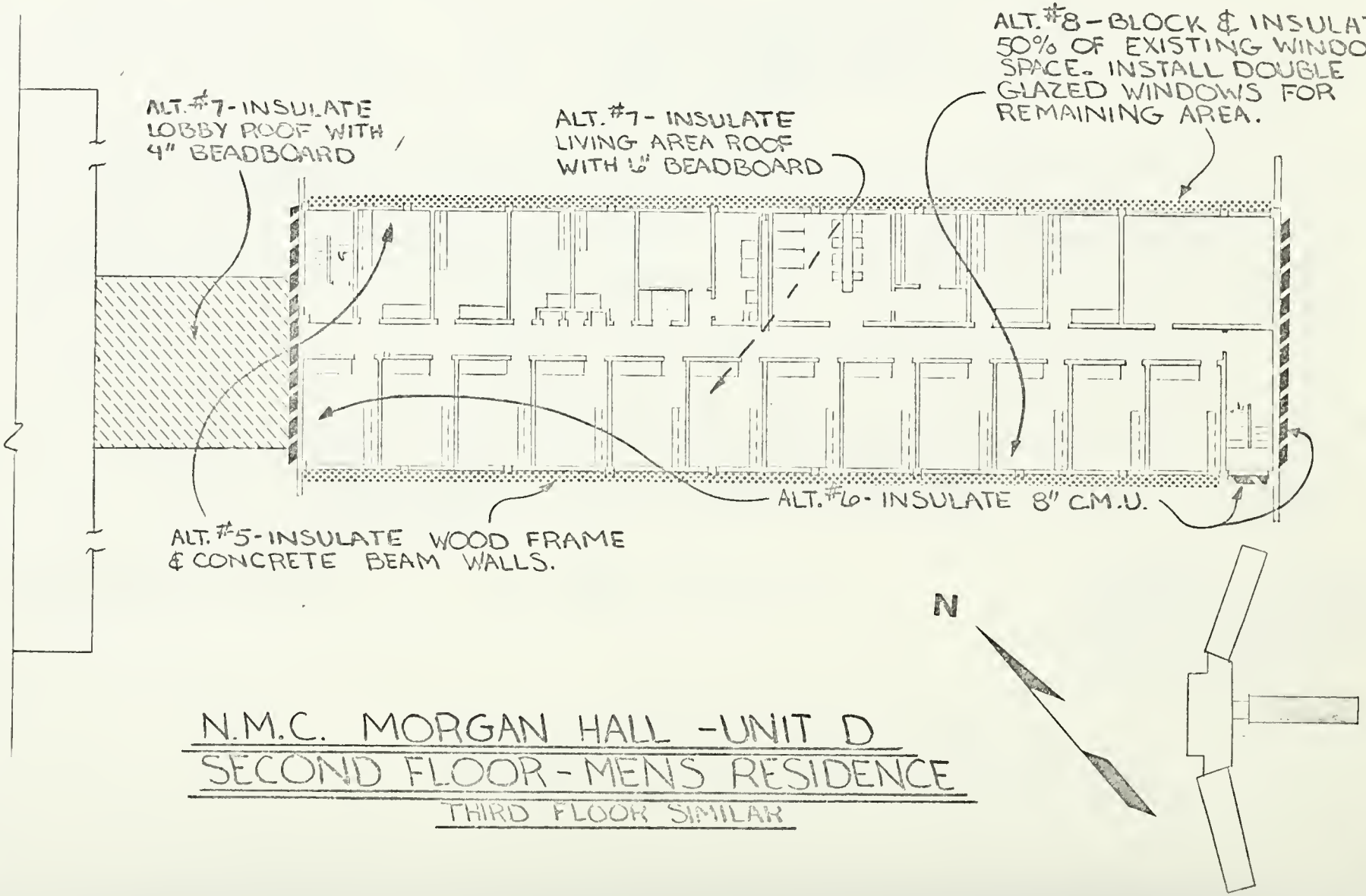
DRAPES ENGINEERING
MECHANICAL & ELECTRICAL ENGINEERS
GREAT FALLS, MONTANA

DATE
SHEET
OF

NORTHERN MONTANA COLLEGE
ADD'N TO MENS DORMITORY
HAVRE, MONTANA

DRAPES ENGINEERING
MECHANICAL & ELECTRICAL ENGINEERS
GREAT FALLS, MONTANA

DATE 9-14-78
SHEET
OF


ALT. #7 - INSULATE LOBBY ROOF WITH 4" BEADBOARD
ALT. #7 - INSULATE LIVING AREA ROOF WITH 6" BEADBOARD
ALT. #8 - BLOCK & INSULATE 50% OF EXISTING WINDOW SPACE. INSTALL DOUBLE GLAZED WINDOWS FOR REMAINING AREA.
ALT. #6 - INSULATE 8" C.M.U.
ALT. #5 - INSULATE WOOD FRAME & CONCRETE BEAM WALLS.
N

# N.M.C. MORGAN HALL - UNIT D

## SECOND FLOOR - MENS RESIDENCE

THIRD FLOOR SIMILAR

TABLE 7.13

LIFE CYCLE COST SUMMARY

NMC MORGAN HALL - MEN'S RESIDENCE

| Alt. | Alternative Description | First Cost ($1000's) | Present Worth of Life Cycle Cost Savings ($1000's) | | Breakeven On First Cost (Yr) | | Percent Energy Savings | EUI BTU / GSF-DD |
|---|---|---|---|---|---|---|---|---|
| | | | Min. | Max. | Min. | Max. | | |
| 1 | Existing Building | - | - | - | - | - | - | 21.94 |
| 2 | Install night setback system | .5 | 52 | 90 | 1 | 1 | 4.5 | 20.95 |
| 3 | Auxiliary DHW heater | 3.2 | 2 | 5 | 21 | 27 | .4 | 21.85 |
| 4 | Insulate boilers & DHW storage tanks | 4.9 | 21 | 40 | 8 | 9 | 2.2 | 21.45 |
| 5 | Insulate wood frame and concrete beam walls | 50 | -10 | 20 | 30 | >35 | 3.5 | 21.17 |
| 6 | Insulate eight-inch CMU walls | 17 | 8 | 26 | 21 | 27 | 2.1 | 21.47 |
| 7 | Insulate roof areas | 33 | 21 | 61 | 20 | 24 | 4.7 | 20.90 |
| 8 | Block and insulate or double-glaze windows | 60 | 225 | 433 | 9 | 10 | 24.5 | 16.56 |

3. LIFE CYCLE CONSERVATION RECOMMENDATIONS

a. The following recommendations, in order of priority, are to conserve energy and reduce the Life Cycle owning and operating costs of the NMC Morgan Hall - Men's Residence.

1. Alternative #6

Install night setback system. This provides an estimated energy savings of 4.5% for an investment of $510.00 with a payback of one year.

2. Alternative #4

Insulate boilers and DHW storage tanks with an additional six inches of fiberglass insulation. This provides an estimated energy savings of 2.2% for an investment of $4,900.00 with a payback of 8 to 9 years (minimum to maximum).

3. Alternative #8

Block and insulate and double-glaze existing window area. This provides an estimated energy savings of 24.5% for an investment of $59,500.00 with a payback of 9 to 10 years.

4. Alternative #7

Insulate the roof of Unit B and the associated lobbies with four inches of glued-on beadboard and insulate the roofs' of Units A, C, and D with six inches of glued-on beadboard. This provides an estimated energy savings of 4.7% for an investment of $33,400.00 with a payback of 20 to 24 years. (Note: This alternative is to be done when the existing roof is replaced.)

3. LIFE CYCLE CONSERVATION RECOMMENDATIONS

5. Alternative #6

Insulate the exterior surface of the concrete block exterior walls with six inches of glued-on beadboard covered with a finish of stucco. This provides an estimated energy savings of 2.1% for an investment of $17,100.00 with a payback of 21 to 27 years.

6. Alternative #3

Valve off one DHW storage tank and install separate gas water heater for summer usage. This provides an estimated energy savings of .4% for an investment of $3,200.00 with a payback of 21 to 27 years.

7. Alternative #5

Insulate the exterior surface of the wood framed and concrete beam exterior walls with six inches of glued-on beadboard covered with a finish of stucco. This provides an estimated energy savings of 3.5% for an investment of $50,500.00 with a payback of 30 years to a time greater than the estimated economic building life.

1. BUILDING DESCRIPTION

a. General

The Student Union Building was constructed in 1959 with an addition built in 1963. The addition increased the first floor area by about one-third the original size.

The building consists of two floors and a basement. The basement is the size of the original building. The existing first floor appears as three rectangular sections with one side common. The second floor is about one-third the size of the first floor and is rectangularly shaped.

The first floor contains a ballroom and over this area the roof is elevated about four feet above the rest of the first floor roof.

In 1969 a food service building was constructed west of the Student Union. A hallway was constructed between the two buildings. Based on occupied/unoccupied conditions, the energy exchange between the two buildings is negligible.

b. Building Envelope

The building's walls are primarily two four-inch brick veneers sandwiching a dead air space and one-inch of rigid insulation. The walls enclosing the raised roof over the ballroom are insulated wood panel. A single wall section near the east entrance consists of an insulated wood facade.

1. BUILDING DESCRIPTION (CONT'D)

All roofs are similar in construction consisting of acoustical tile, gypsum board, batt insulation, dead air space, plywood sheathing and a typical built-up roof. The roof over the snack bar area contains six skylights and the second floor roof contains seven skylights.

The windows are single-glazed and are moderately good fitting; however, some weatherstripping is possible.

c. Heating and Ventilation

Heat is supplied by a gas-fired steam boiler which furnishes steam to three heating and ventilating units, one multizone unit and a few sections of perimeter fin tube. Domestic hot water is supplied by a separate gas-fired heater.

At this time there is no mechanical cooling within the Student Union Building.

2. LIFE CYCLE ENERGY ANALYSIS

a. Description of Alternatives

The following alternatives were investigated for achieving energy conservation.

Alternative #1

This alternative is the existing building "as is". Alternative #1 will be used as the basis for comparison against subsequent alternatives.

Alternative #2

Set fresh air damper to a minimum position when heat is required of H&V Units #1, #2, and #3. Convert multizone H&V Unit #4 into a VAV system.

Alternative #3

Revise night setback for a lower temperature and for a longer period of time.

Alternative #4

Add an additional six inches of insulation to the boiler.

Alternative #5

Insulate exterior surface of exterior walls with six inches of glued-on beadboard insulation covered with a stucco finish.

Alternative #6

Insulate the exterior surface of the roofs with six inches of glued-on beadboard insulation. (Note: This alternative is to be done when the existing roof is replaced.)

Alternative #7

Block and insulate the thirteen skylights.

2. LIFE CYCLE ENERGY ANALYSIS (CONT'D)

Alternative #8

Block and insulate the first floor to match exterior finish all glass surrounding doorway entrances; block and insulate to match exterior finish all windows along the south and north walls, all windows in the west entrance to Room 105, all windows in Room 102, and all windows in Room 113. Block and insulate 60% of all remaining first floor windows to match exterior finish, install vented double-glazed windows in the remaining 40% unblocked area. Block and insulate to match exterior finish all windows along the second floor east wall; block and insulate to match exterior finish 45% of windows along the second floor west wall, install vented double-glazed windows in the remaining 55%.

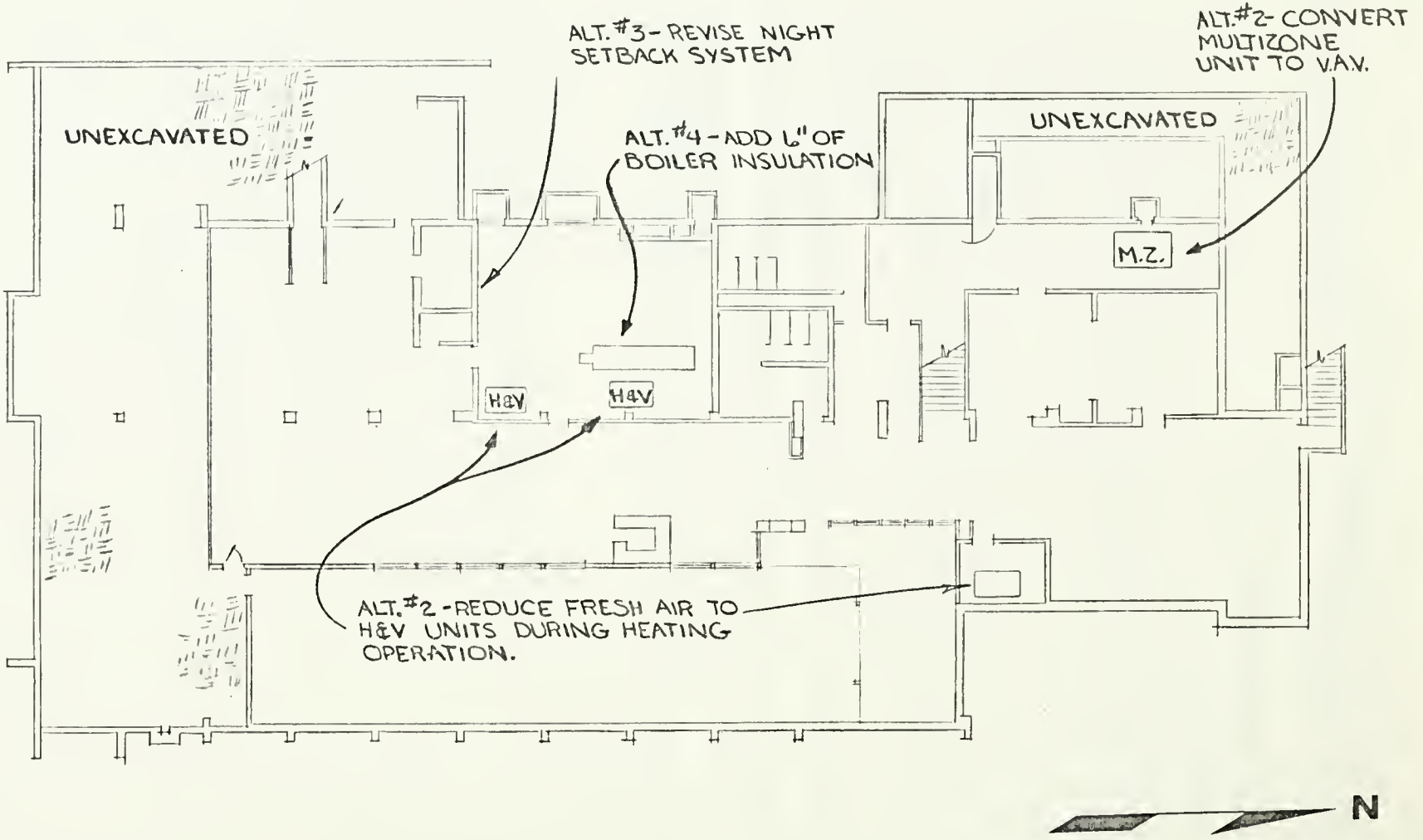
b. Life Cycle Cost Summary

Table 7.14 is a summary of the Life Cycle Cost Analysis of each alternative showing the estimated first cost, the present worth of life cycle cost savings, the breakeven point or payback of first cost in years, the percent energy savings, and the energy consumption in Btu/gross square foot of building area/degree day of each alternative.

N.M.C. STUDENT UNION
BASEMENT FLOOR
HAVRE, MONTANA

DRAPES ENGINEERING
MECHANICAL & ELECTRICAL ENGINEERS
GREAT FALLS, MONTANA

DATE 12-5-78
SHEET
OF

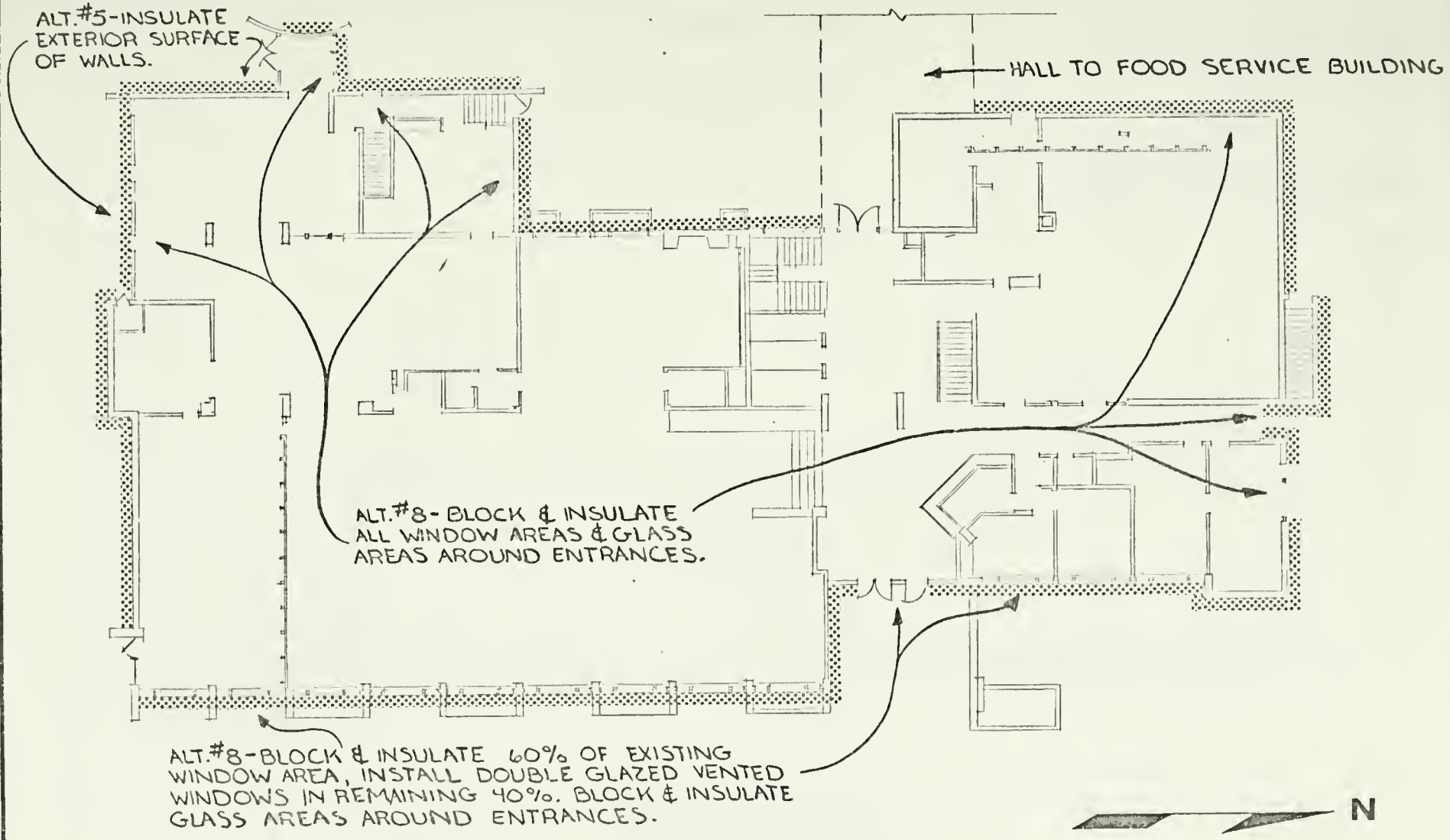



# N.M.C. STUDENT UNION - BASEMENT

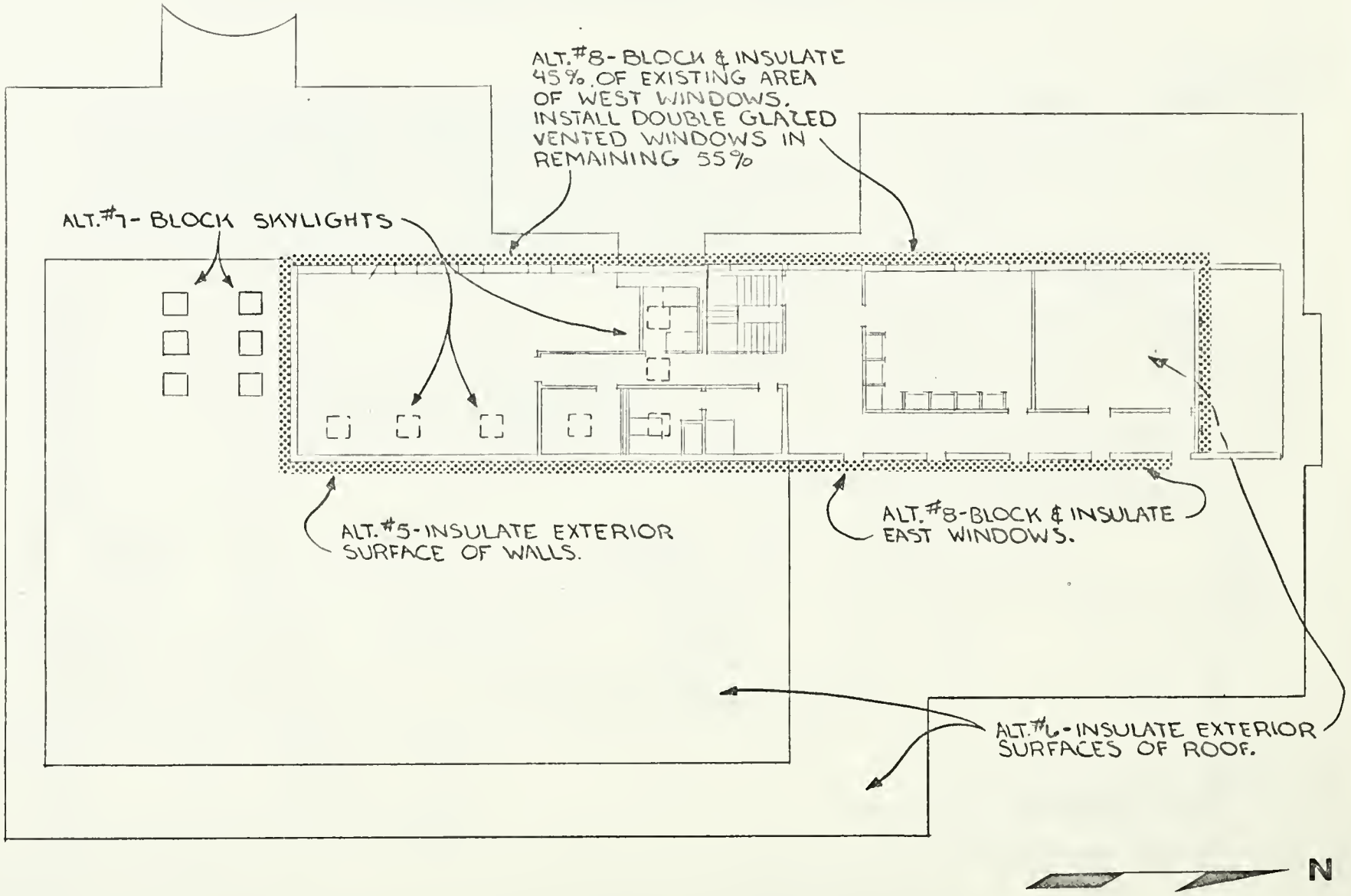
NMC STUDENT UNION
FIRST FLOOR
HAVRE, MONTANA

DRAPES ENGINEERING
MECHANICAL & ELECTRICAL ENGINEERS
GREAT FALLS, MONTANA

DATE 6-76
SHEET
OF


ALT.#5-INSULATE EXTERIOR SURFACE OF WALLS.
HALL TO FOOD SERVICE BUILDING
ALT.#8- BLOCK & INSULATE ALL WINDOW AREAS & GLASS AREAS AROUND ENTRANCES.
ALT.#8-BLOCK & INSULATE 60% OF EXISTING WINDOW AREA, INSTALL DOUBLE GLAZED VENTED WINDOWS IN REMAINING 40%. BLOCK & INSULATE GLASS AREAS AROUND ENTRANCES.
N

# N.M.C. STUDENT UNION - FIRST FLOOR


ALT.#8- BLOCK & INSULATE 45% OF EXISTING AREA OF WEST WINDOWS. INSTALL DOUBLE GLAZED VENTED WINDOWS IN REMAINING 55%
ALT.#7- BLOCK SKYLIGHTS
ALT.#5-INSULATE EXTERIOR SURFACE OF WALLS.
ALT.#8-BLOCK & INSULATE EAST WINDOWS.
ALT.#6-INSULATE EXTERIOR SURFACES OF ROOF.
N

# N.M.C. STUDENT UNION - SECOND FLOOR

N.M.C. STUDENT UNION
SECOND FLOOR PLAN
HAVRE, MONTANA

DRAPES ENGINEERING
MECHANICAL & ELECTRICAL ENGINEERS
GREAT FALLS, MONTANA

DATE 12-3-78
SHEET
OF

TABLE 7.14

LIFE CYCLE COST SUMMARY

NMC STUDENT UNION BUILDING

| Alt. | Alternative Description | First Cost ($1000's) | Present Worth of Life Cycle Cost Savings ($1000's) Min. | Max. | Breakeven On First Cost (Yr) Min. | Max. | Percent Energy Savings | EUI BTU/GSF-DD |
|---|---|---|---|---|---|---|---|---|
| 1 | Existing Building | - | - | - | - | - | - | 9.48 |
| 2 | Reduce fresh air to H&V units and convert multizone to VAV. | 4.4 | 9 | 22 | 14 | 17 | 3.7 | 9.13 |
| 3 | Revise night setback system. | .3 | 33 | 64 | 1 | 1 | 9.5 | 8.58 |
| 4 | Insulate boiler. | 1.5 | 7 | 16 | 9 | 9 | 2.6 | 9.23 |
| 5 | Insulate exterior surface of exterior walls. | 34 | 9 | 47 | 26 | 34 | 12.0 | 8.34 |
| 6 | Insulate exterior surface of roof. | 23 | 13 | 46 | 23 | 29 | 10.2 | 8.51 |
| 7 | Block and insulate skylights. | .4 | 10 | 20 | 3 | 3 | 3.0 | 9.91 |
| 8 | Block and insulate or double-glaze windows. | 30 | 36 | 96 | 18 | 22 | 18.7 | 7.70 |

3. LIFE CYCLE CONSERVATION RECOMMENDATIONS

a. The following recommendations, in order of priority, are to conserve energy and reduce the Life Cycle owning and operating costs of the NMC Student Union Building.

1. Alternative #3

Revise night setback for a lower temperature and for a longer period of time. This provides an estimated energy savings of 9.5% for an investment of $270.00 with a payback of one year.

2. Alternative #7

Block and insulate the thirteen skylights. This provides an estimated energy savings of 3.0% for an investment of $450.00 with a payback of three years.

3. Alternative #4

Add an additional six inches of insulation to the boiler. This provides an estimated energy savings of 2.6% for an investment of $1,500.00 with a payback of nine years.

4. Alternative #2

Set fresh air damper to a minimum position when heat is required of H&V Units #1, #2, and #3. Convert multizone H&V Unit #4 into a VAV system. This provides an estimated energy savings of 3.7% for an investment of $4,400.00 with a payback of 14 to 17 years (minimum to maximum).

5. Alternative #8

Replace existing window areas by blocking and insulating the opening or installing new double-glazed window units. This provides an estimated energy savings of 18.7% for an investment of $30,200.00 with a payback of 18 to 22 years.

3. LIFE CYCLE CONSERVATION RECOMMENDATIONS

6. Alternative #6

Insulate the exterior surface of the roofs with 6 inches of glued-on beadboard insulation. (Note: This alternative is to be done when the existing roof is replaced.) This provides an estimated energy savings of 10.2% for an investment of $23,200.00 with a payback of 25 to 29 years.

5. Alternative #5

Insulate exterior surface of exterior walls with six inches of glued-on beadboard insulation covered with a stucco finish. This provides an estimated energy savings of 12% for an investment of $33,600.00 with a payback of 26 to 34 years.

1. BUILDING DESCRIPTION

a. General

The Center for the Aged was built in about 1952. An aerial view of this building resembles a snowflake -- six branches reach out from a central core. The center area contains the office space and kitchen facilities, covers approximately 11,000 square feet and has a basement under it. The boilers and other mechanical equipment are located in this basement.

Four wings pointing in the northwest, southwest, and southeast and northeast directions are connected to the center core area. Each of these branches cover about 4,000 square feet and contain living quarters and physical therapy rooms. All these units are one-story high.

In 1976, two wings running east and west were added. These wings cover about 8,000 square feet each and enclose living quarters. Additionally, a 2,000 square foot chapel was added to the north side of the central area.

b. Building Envelope

All of the 1952 construction used plaster walls on 8" tile with 4" face brick on the exterior. No insulation was used in these walls. The ceilings in the original wings are plaster on wood lath with 3" of batt insulation. Most of this ceiling insulation is in poor condition. Approximately 60% of the ceiling in the central area has been reinsulated with 6" of batt insulation. The remainder of this area also has 3" in poor condition.

1. BUILDING DESCRIPTION (CONT'D)

The 1976 addition used face brick on the exterior walls to match the existing building. These walls used 3-1/2" batt insulation with gypsum board interiors. The pitched roofs of these new wings were insulated with 6" of batt insulation.

All glazing throughout the building is single-glazed. All room windows are operable. Window units have been well maintained.

c. Heating and Ventilating Systems

All of the building heating is supplied from two 6,173 MBh KWANEE #587 steam boilers. Each boiler is capable of carrying the entire heating load in the building, so they are operated separately on six month intervals.

The original wings are heated with a two-pipe steam system using wall convectors with individual room thermostats. The only ventilation in these wings is provided by infiltrated air which makes up for the exhaust system which draws air from the toilet areas and hallway and exhausts out the ceiling in the central area. In addition to the exhaust ventilation, a physical therapy room in each wing is heated by two unit ventilators which introduce a minimum setting of fresh air during the heating cycle.

The new wings which run east and west are heated with hot water wall convectors using individual room thermostats. In addition to this perimeter heating, an air handling unit supplies heated air with a minimum fresh air setting to the living quarters.

1. BUILDING DESCRIPTION (CONT'D)

The central area is heated and ventilated with a large H&V unit. Heating in this unit is provided by steam coils, and it is controlled so that minimum fresh air is used during the heating cycle.

2. LIFE CYCLE ENERGY ANALYSIS

a. Description of Alternatives

The following alternatives were investigated for achieving energy conservation.

Alternative #1

This alternative is the existing building "as is". Alternative #1 will be used as the basis for comparison against subsequent alternatives.

Alternative #2

Install night setback thermostats in place of individual room thermostats and other zone thermostats. These thermostats have an override setting so that setback is ignored on command from the occupant. Normal daytime set temperature is $75^{o}$F. The setback temperature of $65^{o}$F is maintained from 11:00 p.m. to 5:00 a.m. The exhaust fans for wings A, B, C, D and E are also shut off during the setback period.

Alternative #3

Install a steam boiler capable of supplying domestic hot water needs. This makes it possible to shut down the main boilers during the summer months.

Alternative #4

Install boiler flue dampers and electronic ignition on the two main boilers. Reinsulate the boilers with an additional 3" of insulation.

Alternative #5

Reinsulate the ceilings in the original wings (A, B, D & E), using 15 inches of loose fill insulation.

2. LIFE CYCLE ENERGY ANALYSIS (CONT'D)

Alternative #6

Replace all single-glazed window units with double-glazed units. Reinstall operable windows where they presently exist. Make all weatherstripping as airtight as possible.

Alternative #7

Apply 8 inches of exterior beadboard insulation on the outside wall surfaces of wings A, B, D and E.

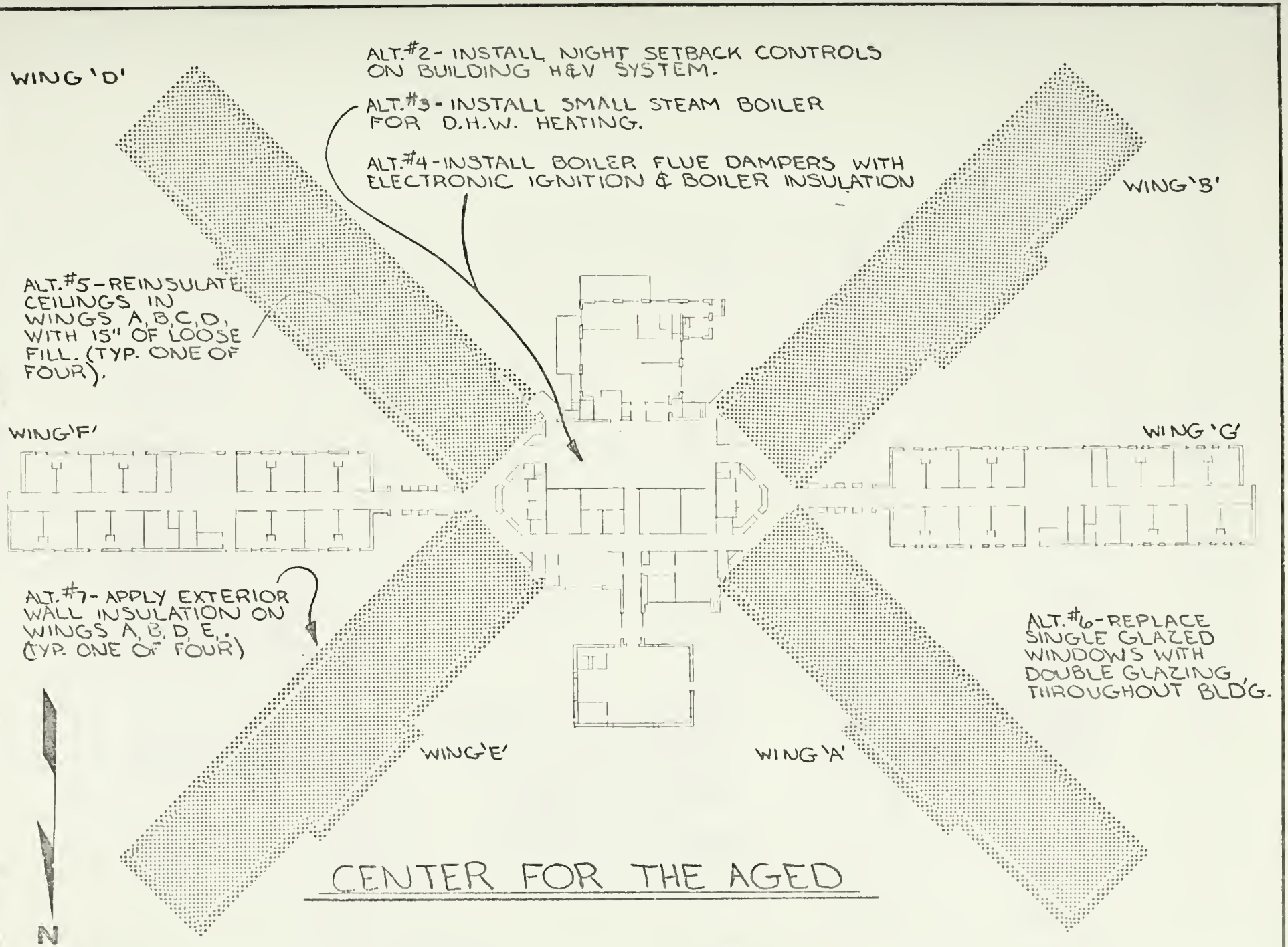
b. Life Cycle Cost Summary

Table 7.15is a summary of the Life Cycle Cost Analysis of each alternative showing the estimated first cost, the present worth of life cycle cost savings, the breakeven point or payback of first cost in years, the percent energy savings, and the energy consumption in Btu/gross square foot of building area/degree day of each alternative.

CENTER FOR THE AGED
FIRST FLOOR PLAN
LEWISTOWN, MONTANA

DRAPES ENGINEERING
MECHANICAL & ELECTRICAL ENGINEERS
GREAT FALLS, MONTANA

DATE 6-77
SHEET
OF


WING 'D'
ALT.#2 - INSTALL NIGHT SETBACK CONTROLS ON BUILDING H&V SYSTEM.
ALT.#3 - INSTALL SMALL STEAM BOILER FOR D.H.W. HEATING.
ALT.#4 - INSTALL BOILER FLUE DAMPERS WITH ELECTRONIC IGNITION & BOILER INSULATION
WING 'B'
ALT.#5 - REINSULATE CEILINGS IN WINGS A, B, C, D, WITH 15" OF LOOSE FILL. (TYP. ONE OF FOUR).
WING 'F'
WING 'G'
ALT.#7 - APPLY EXTERIOR WALL INSULATION ON WINGS A, B, D, E, (TYP. ONE OF FOUR)
ALT.#6 - REPLACE SINGLE GLAZED WINDOWS WITH DOUBLE GLAZING THROUGHOUT BLD'G.
WING 'E'
WING 'A'
N

CENTER FOR THE AGED

TABLE 7.15

LIFE CYCLE COST SUMMARY

CENTER FOR THE AGED

| Alt. | Alternative Description | First Cost ($1000's) | Present Worth of Life Cycle Cost Savings ($1000's) | | Breakeven On First Cost (Yr) | | Percent Energy Savings | EUI BTU/GSF-DD |
|---|---|---|---|---|---|---|---|---|
| | | | Min. | Max. | Min. | Max. | | |
| 1 | Existing Building | - | - | - | - | - | - | 27.15 |
| 2 | Install night setback controls | 17 | 100 | 212 | 8 | 8 | 4.8 | 25.86 |
| 3 | Install separate domestic hot water boiler | 6.5 | 114 | 222 | 4 | 4 | 5.0 | 25.78 |
| 4 | Reinsulate boilers & install flue dampers w/electric ignition | 4.1 | 40 | 80 | 6 | 6 | 1.8 | 26.65 |
| 5 | Reinsulate ceilings in wings A, B, D & E | 80 | 52 | 171 | 22 | 28 | 5.6 | 25.64 |
| 6 | Replace all windows with double-glazed units | 126 | 37 | 184 | 25 | 34 | 6.9 | 25.28 |
| 7 | Insulate outside walls with exterior insulation | 57 | 76 | 196 | 17 | 21 | 5.6 | 25.62 |

3. LIFE CYCLE CONSERVATION RECOMMENDATIONS

a. The following alternatives, in order of priority, are recommended to conserve energy and reduce the Life Cycle owning and operating costs of the Center for the Aged.

1. Alternative #3

Install a separate boiler for hot water heating. This provides an estimated energy savings of 5.0% for an investment of $6,500.00 with a payback of four years.

2. Alternative #4

Reinsulate boilers and install flue dampers with electronic ignition. This provides an estimated energy savings of 1.8% for an investment of $4,100.00 with a payback of six years.

3. Alternative #2

Install night setback controls. This provides an estimated energy savings of 4.8% for an investment of $17,000.00 with a payback of eight years.

4. Alternative #7

Insulate outside walls with exterior insulation. This provides an estimated energy savings of 5.6% for an investment of $57,000.00 with a payback of 17 to 21 years (minimum to maximum).

5. Alternative #5

Reinsulate ceilings with loose fill insulation in original wings. This provides an estimated energy savings of 5.6% for an investment of $80,000.00 with a payback of 22 to 28 years.

3. LIFE CYCLE CONSERVATION RECOMMENDATIONS (CONT'D)

6. Alternative #6

Replace all windows with double-glazed window units. This provides an estimated energy savings of 6.9% for an investment of $126,000.00 with a payback of 25 to 34 years.

1. BUILDING DESCRIPTION

a. General

The art annex is connected to the west side of the swimming pool building on the site of the old skating rink. The same barrel roof running in an east-west line, covers both structures. The annex encloses a number of separate work spaces separated by partitioned walls on the ground floor. These spaces represent various functions such as kiln, welding, clay work, etc. The attic space under the barrel roof is unused except for a room enclosing the multizone unit.

b. Building Envelope

All art annex exterior walls are uninsulated concrete block walls. The only window areas, located on the north and south walls, consist of a single layer of corregated translucent fiberglass. The west wall, under the curved barrel roof and above the CMU wall, is of wood frame construction. The roof is a curved wood deck with built-up roofing and is uninsulated. However, the attic over the annex is insulated to about R19 with fiberglass batt insulation. The east end of the annex adjoins the swimming pool building.

c. Heating, Ventilation and Air-Conditioning System

Heating, cooling and ventilating for the entire annex is provided through a six-zone multizone unit located in the attic space adjacent to the west wall. Additionally, there are special purpose equipment in some areas. The welding area has its own separate exhaust system with heated makeup air. The paint booth has its own exhaust unit. The kiln

1. BUILDING DESCRIPTION (CONT'D)

area uses an outside air system for cooling. The heat in the kiln is provided by natural gas which is metered separately from the building steam and electric energy use. Fluorescent lighting is used throughout the annex building.

2. LIFE CYCLE ENERGY ANALYSIS

a. Description of Alternatives

The following alternatives were investigated for achieving energy conservation.

Alternative #1

This alternative is the existing building "as is". Alternative #1 will be used as the basis for comparison against subsequent alternatives.

Alternative #2

Insulate the ceiling to a total R value of 35 using loose fill cellulose blown-in insulation.

Alternative #3

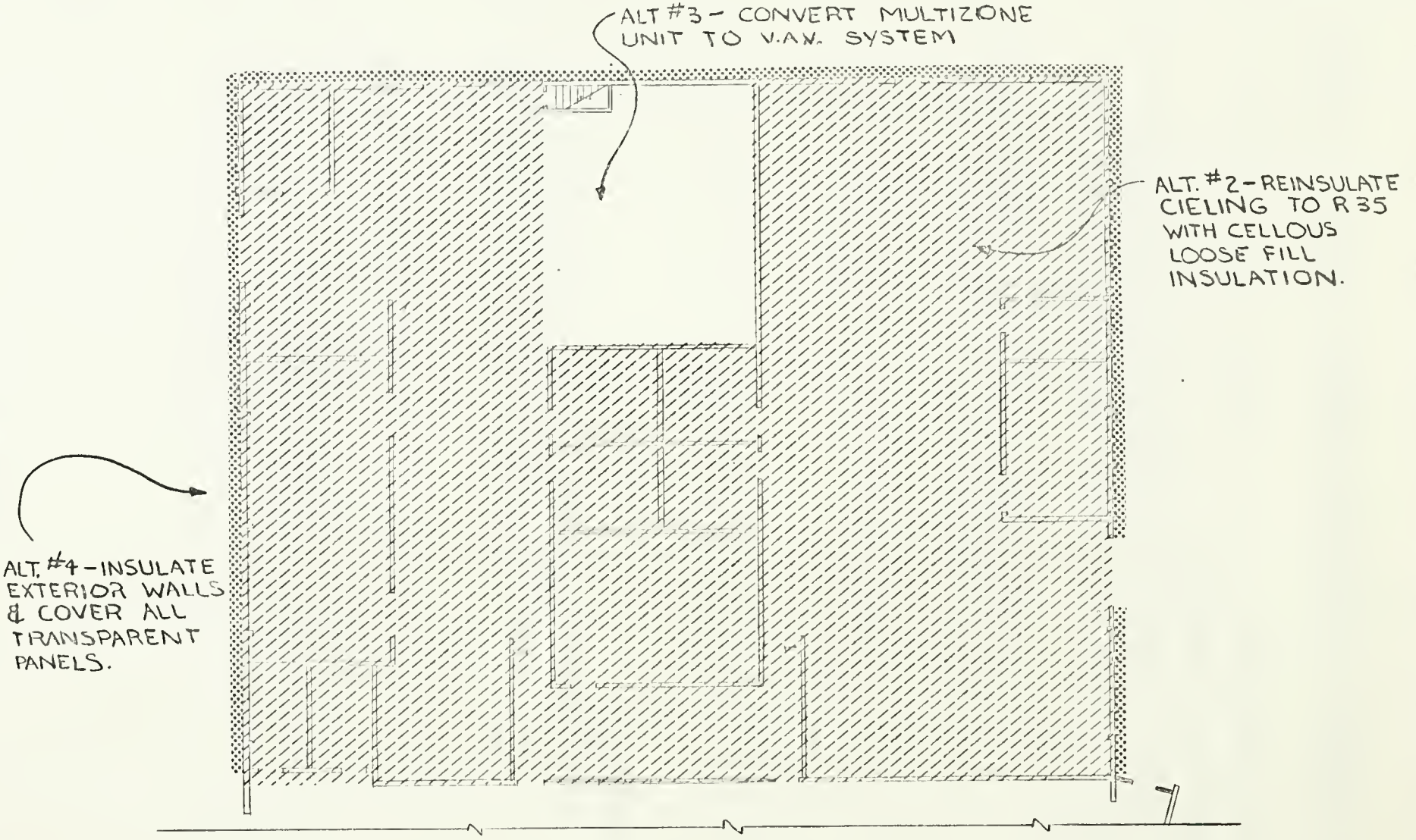
Modify the existing multizone unit to operate as a variable air volume system.

Alternative #4

Insulate the exterior walls with six inches of glued-on beadboard insulation with a stucco exterior finish. Cover over all transparent areas.

b. Life Cycle Cost Summary

Table 7.16 is a summary of the Life Cycle Cost Analysis of each alternative showing the estimated first cost, the present worth of life cycle cost savings, the breakeven point of payback of first cost in years, the percent energy savings, and the energy consumption in Btu/gross square foot of building area/degree day of each alternative.


ALT #3 - CONVERT MULTIZONE UNIT TO V.A.V. SYSTEM
ALT. #2 - REINSULATE CIELING TO R 35 WITH CELLOUS LOOSE FILL INSULATION.
ALT. #4 - INSULATE EXTERIOR WALLS & COVER ALL TRANSPARENT PANELS.

# ART ANNEX FLOOR PLAN

U. OF M. ART ANNEX
FLOOR PLAN
MISSOULA MONTANA

DRAPES ENGINEERING
MECHANICAL & ELECTRICAL ENGINEERS
GREAT FALLS, MONTANA

DATE 8-7-73
SHEET
OF

TABLE 7.16

LIFE CYCLE COST SUMMARY

UNIVERSITY OF MONTANA ART ANNEX

| Alt. | Alternative Description | First Cost ($1000's) | Present Worth of Life Cycle Cost Savings ($1000's) | | Breakeven On First Cost (Yr) | | Percent Energy Savings | EUI BTU/GSF-DD |
|---|---|---|---|---|---|---|---|---|
| | | | Min. | Max. | Min. | Max. | | |
| 1 | Existing Building | - | - | - | - | - | - | 23.76 |
| 2 | Reinsulate Ceiling | 3.5 | 4.1 | 9.3 | 16 | 19 | 1.9 | 23.30 |
| 3 | Convert existing multizone unit to variable air volume system. | 27 | 77 | 150 | 10 | 11 | 26.5 | 17.47 |
| 4 | Insulate Exterior Walls | 23 | 38 | 80 | 14 | 16 | 15.5 | 20.08 |

3. LIFE CYCLE CONSERVATION RECOMMENDATIONS

a. The following alternatives, in order of priority, are recommended to conserve energy and reduce the Life Cycle owning and operating costs of the University of Montana Art Annex.

1. Alternative #3

Convert the existing multizone unit to a variable air volume system. This provides an estimated energy savings of 26.5% for an investment of $26,600.00 with a payback of 10 to 11 years (minimum to maximum).

2. Alternative #4

Insulate all exterior walls. This provides an estimated energy savings of 15.5% for an investment of $22,900.00 with a payback of 14 to 16 years.

3. Alternative #2

Reinsulate the annex ceiling. This provides an estimated energy savings of 1.9% for an investment of $3,500.00 with a payback of 16 to 19 years.

1. BUILDING DESCRIPTION

a. General

Elrod Hall is a three floor residence hall designed in 1921. The building is 210 feet long and 37 feet wide and is oriented in an east-west direction. Additionally there is a one-story projection on the south side which was originally a kitchen. This area is no longer used as a kitchen. The north west corner of the building has been attached to Brantly Hall as indicated in the enclosed drawing.

b. Building Envelope

Wall construction throughout Elrod Hall uses 4" face brick on 4½" tile. Interior walls are plaster on wood lath. There is no wall insulation. All windows are single-glazed, wood frame, double hung units which are loose fitting and generally in poor condition. The ceiling in the third floor is plaster on wood lath and has no insulation. There is an open attic with easy access above this ceiling.

c. Heating and Ventilating System

The entire building is heated with a two-pipe steam radiator system. The steam is supplied directly from the central steam system on the campus. Heating in individual rooms and other areas is controlled by hand valves on each radiator. Exposed supply piping in the rooms has caused overheat problems during moderate winter weather. Overheating under these conditions is typically controlled by opening windows.

Unit ventilators are located at the ends of the hallways on each floor. These units are controlled by thermostats located directly above the unit.

1. BUILDING DESCRIPTION (CONT'D)

Toilet exhaust fans are presently operated 24 hours per day, all year long, even when the building is unoccupied in the summer time.

2. LIFE CYCLE ENERGY ANALYSIS

a. Description of Alternatives

The following alternatives were investigated for achieving energy conservation.

Alternative #1

This alternative is the existing building "as is". Alternative #1 will be used as the basis for comparison against subsequent alternatives.

Alternative #2

Install new control valves on each radiator. Control these new valves with individual room thermostats. Provide a night setback control for the whole system.

Alternative #3

Control the operation of the toilet exhaust fans by interfacing with the central computer. Shut them off completely during periods when the building is unoccupied and shut off six hours per day on a daily schedule.

Alternative #4

Insulate exposed steam supply and return piping in dormitory rooms. Provide sheet metal cover over insulated piping.

Alternative #5

Insulate the domestic hot water tank in the basement.

Alternative #6

Insulate the ceiling over the entire building with 16" of loose fill insulation.

Alternative #7

Replace all window units throughout the building with double-glazed window units. Install operable units in dormitory rooms.

2. LIFE CYCLE ENERGY ANALYSIS (CONT'D)

Alternative #8

Insulate all exterior walls with 6" of beadboard. Cover exterior with stucco.

b. Life Cycle Cost Summary

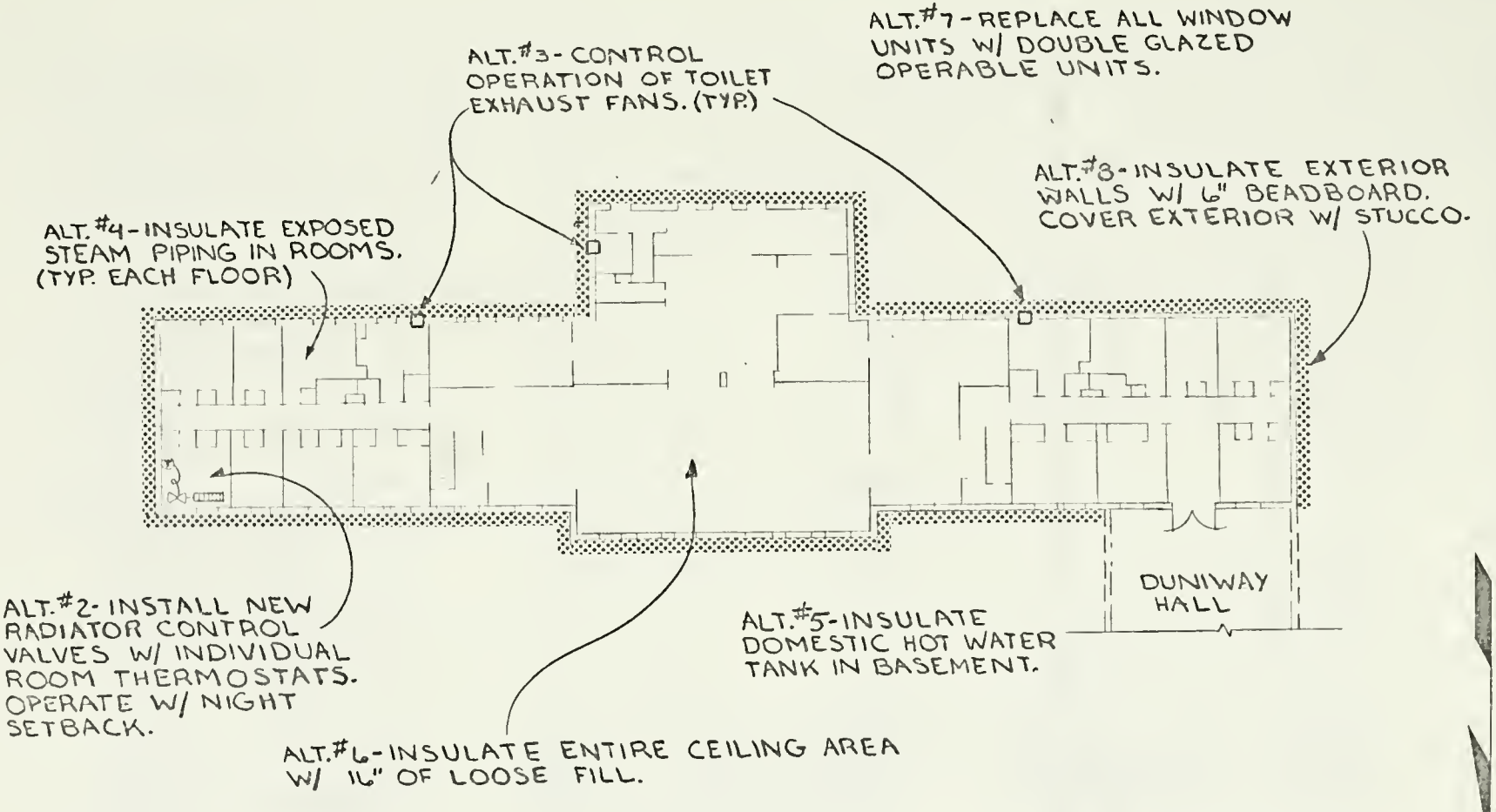
Table 7.17is a summary of the Life Cycle Cost Analysis of each alternative showing the estimated first cost, the present worth of life cycle cost savings, the breakeven point or payback of first cost in years, the percent energy savings, and the energy consumption in Btu/gross square foot of building area/degree day of each alternative.

UNIVERSITY OF MONTANA
ELROD HALL FIRST FLOOR
MISSOULA, MONTANA

DRAPES ENGINEERING
MECHANICAL & ELECTRICAL ENGINEERS
GREAT FALLS, MONTANA

DATE 7-15-13
SHEET
OF

7.167


ALT.#7 - REPLACE ALL WINDOW UNITS W/ DOUBLE GLAZED OPERABLE UNITS.
ALT.#3 - CONTROL OPERATION OF TOILET EXHAUST FANS. (TYP.)
ALT.#8 - INSULATE EXTERIOR WALLS W/ 6" BEADBOARD. COVER EXTERIOR W/ STUCCO.
ALT.#4 - INSULATE EXPOSED STEAM PIPING IN ROOMS. (TYP. EACH FLOOR)
DUNIWAY HALL
ALT.#2 - INSTALL NEW RADIATOR CONTROL VALVES W/ INDIVIDUAL ROOM THERMOSTATS. OPERATE W/ NIGHT SETBACK.
ALT.#5 - INSULATE DOMESTIC HOT WATER TANK IN BASEMENT.
ALT.#6 - INSULATE ENTIRE CEILING AREA W/ 16" OF LOOSE FILL.
N

# ELROD HALL — FIRST FLOOR

TABLE 7.17

LIFE CYCLE COST SUMMARY

U OF M ELROD HALL

| Alt. | Alternative Description | First Cost ($1000's) | Present Worth of Life Cycle Cost Savings ($1000's) | | Breakeven On First Cost (Yr) | | Percent Energy Savings | EUI BTU/GSF-DD |
|---|---|---|---|---|---|---|---|---|
| | | | Min. | Max. | Min. | Max. | | |
| 1 | Existing Building | - | - | - | - | - | - | 14.13 |
| 2 | Install new valves with room thermostats | 19 | 60 | 114 | 10 | 11 | 11.8 | 12.46 |
| 3 | Control operation of exhaust fans | 1.2 | 77 | 132 | 1 | 1 | 11.8 | 12.46 |
| 4 | Insulate radiator piping in rooms | 21 | 2.5 | 10 | 29 | 35 | 2.7 | 13.74 |
| 5 | Insulate DHW tank | 1.0 | 14 | 25 | 4 | 4 | 2.3 | 13.81 |
| 6 | Insulate ceiling with 16" of loose fill | 22 | 61 | 118 | 11 | 12 | 12.4 | 12.38 |
| 7 | Replace all windows with double-glaze units | 72 | 166 | 330 | 12 | 13 | 35.7 | 9.09 |
| 8 | Insulate exterior walls with 6" beadboard | 27 | 38 | 83 | 15 | 18 | 9.8 | 12.74 |

3. LIFE CYCLE CONSERVATION RECOMMENDATIONS

a. The following alternatives, in order of priority, are recommended to conserve energy and reduce the Life Cycle owning and operating costs of the University of Montana Elrod Hall.

1. Alternative #3

Control operation of exhaust fans. This provides an estimated energy savings of 11.8% for an investment of $1,200.00 with a payback of one year.

2. Alternative #5

Insulate the domestic hot water tank. This provides an estimated energy savings of 2.3% for an investment of $1,000.00 with a payback of four years.

3. Alternative #2

Install new steam valves with individual room controls. This provides an estimated energy savings of 11.8% for an investment of $19,000.00 with a payback of ten to eleven years (minimum to maximum).

4. Alternative #6

Insulate the ceiling with 16" of loose fill insulation. This provides an estimated energy savings of 12.4% for an investment of $22,000.00 with a payback of eleven to twelve years.

5. Alternative #7

Replace all windows with double-glazed units. This provides an estimated energy savings of 35.7% for an investment of $72,000.00 with a payback of twelve to thirteen years.

3. LIFE CYCLE CONSERVATION RECOMMENDATIONS (CONT'D)

6. Alternative #8

Insulate exterior walls with 6" of beadboard covered with a stucco exterior. This provides an estimated energy savings of 9.8% for an investment of $27,000.00 with a payback of 15 to 18 years.

7. Alternative #4

Insulate exposed steam piping in dormitory rooms. This provides an estimated energy savings of 2.7% for an investment of $21,000.00 with a payback of 29 to greater than 35 years.

1. BUILDING DESCRIPTION

a. General

The University of Montana Field House serves as the major physical education and sports facility for the campus. The 170,000 square foot building encloses the main arena area with bleachers. The basement level adjacent to the arena area includes a weight room, wrestling room, locker rooms and handball courts. The main floor level includes the gymnasium, handball courts, varsity locker room, human performance lab and ticket lobby in addition to the main arena area. The ticket lobby, gymnasium and handball court areas are enclosed under separate flat roof areas from the arena area. The main arena area including the bleachers, varsity locker room and human performance lab are enclosed under a large barrel roof which runs in a north-south line.

b. Building Envelope

Exterior walls under the barrel roof enclosure are one-foot thick uninsulated concrete or uninsulated concrete block. The ticket lobby has all uninsulated concrete block wall construction. The gymnasium addition has one foot thick uninsulated concrete block wall construction on all sides except the east wall which is of wood frame construction with insulation. All flat roof areas are insulated with two inches of fiberglass batt insulation under an outside roof with built up roofing. The barrel roof is a wood deck with built up roofing and presently has two inches of batt insulation stapled to the inside. All glazing is single-pane glass.

1. BUILDING DESCRIPTION (CONT'D)

c. Heating, Ventilation and Air-Conditioning System

Four large heating and ventilating units in the main arena area introduce fresh air into the building. Most of the smaller heating and ventilating units serving peripheral areas draw their fresh air from the arena area. Heating is provided by steam heating coils. Cooling is accomplished by introducing 100% outside air at nighttime. All mechanical systems operate on an occupied-unoccupied cycle and are controlled by the central computer system on the University campus.

2. LIFE CYCLE ENERGY ANALYSIS

a. Description of Alternatives

The following alternatives were investigated for achieving energy conservation.

Alternative #1

This alternative is the existing building "as is". Alternative #1 will be used as the basis for comparison against subsequent alternatives.

Alternative #2

Reinsulate the inside of the barrel roof with ten-inch thick fiberglass batts.

Alternative #3

Insulate the south glass wall of the barrel roof enclosure by painting the glass then glueing on ten inches of beadboard on the inside.

Alternative #4

Insulate the north wall of the barrel roof enclosure with ten inches of beadboard insulation.

Alternative #5

Remove the glazing on the west wall of the ticket office. Frame in the openings with 3-1/2 inch insulated frame walls and finish to match interior and exterior surfaces.

Alternative #6

Reinsulate the ticket office ceiling with ten-inch fiberglass batts.

Alternative #7

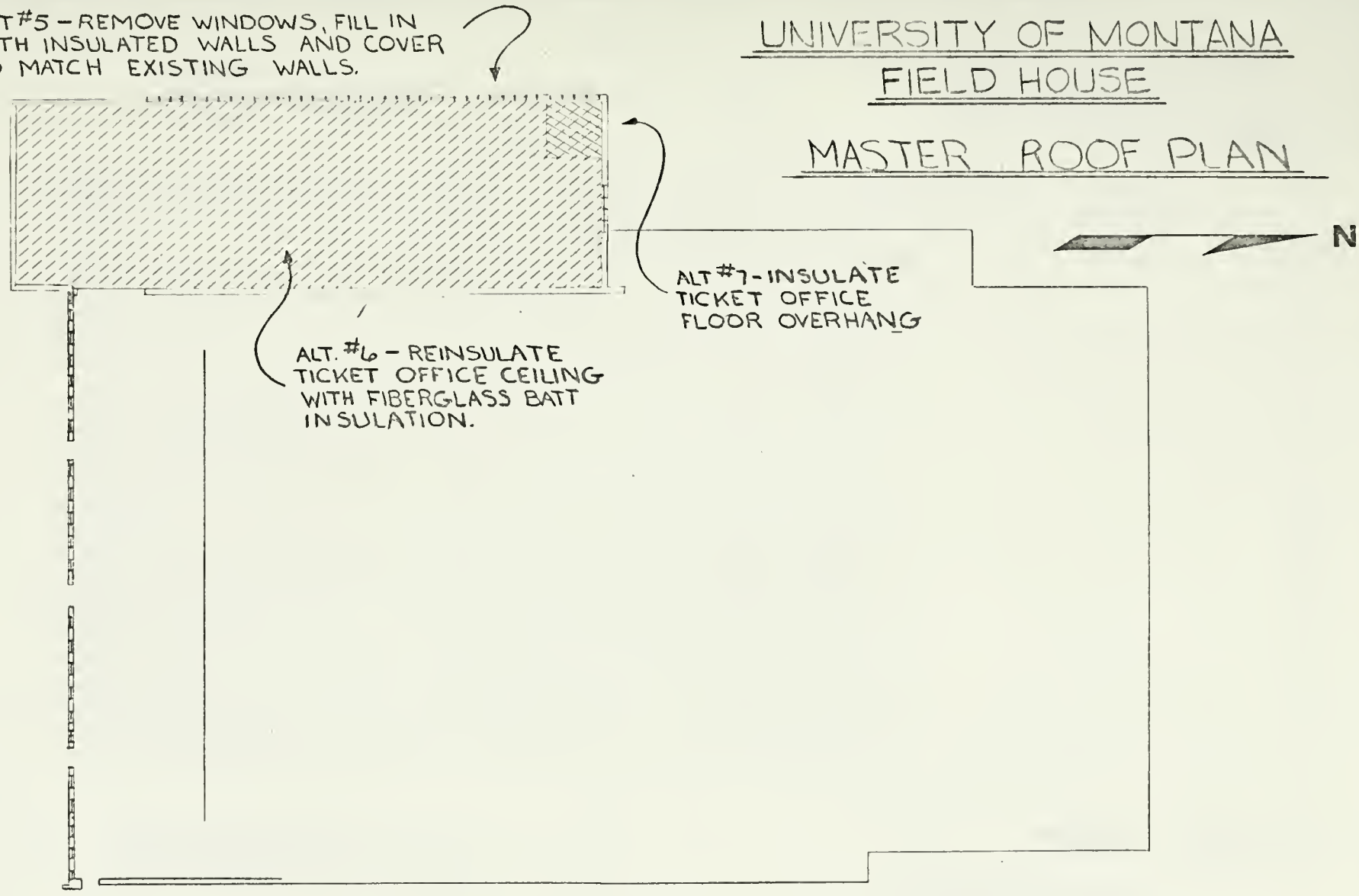
Insulate the ticket office floor overhang on the northwest corner of the ticket office.

2. LIFE CYCLE ENERGY ANAYSIS (CONT'D)

b. Life Cycle Cost Summary

Table 7.18 is a summary of the Life Cycle Cost Analysis of each alternative showing the estimated first cost, the present worth of life cycle cost savings, the breakeven point or payback of first cost in years, the percent energy savings, and the energy consumption in Btu/gross square foot of building area/degree day of each alternative.

# UNIVERSITY OF MONTANA
## FIELD HOUSE
## MASTER ROOF PLAN


ALT #5 - REMOVE WINDOWS, FILL IN WITH INSULATED WALLS AND COVER TO MATCH EXISTING WALLS.
ALT #7 - INSULATE TICKET OFFICE FLOOR OVERHANG
ALT. #6 - REINSULATE TICKET OFFICE CEILING WITH FIBERGLASS BATT INSULATION.
N

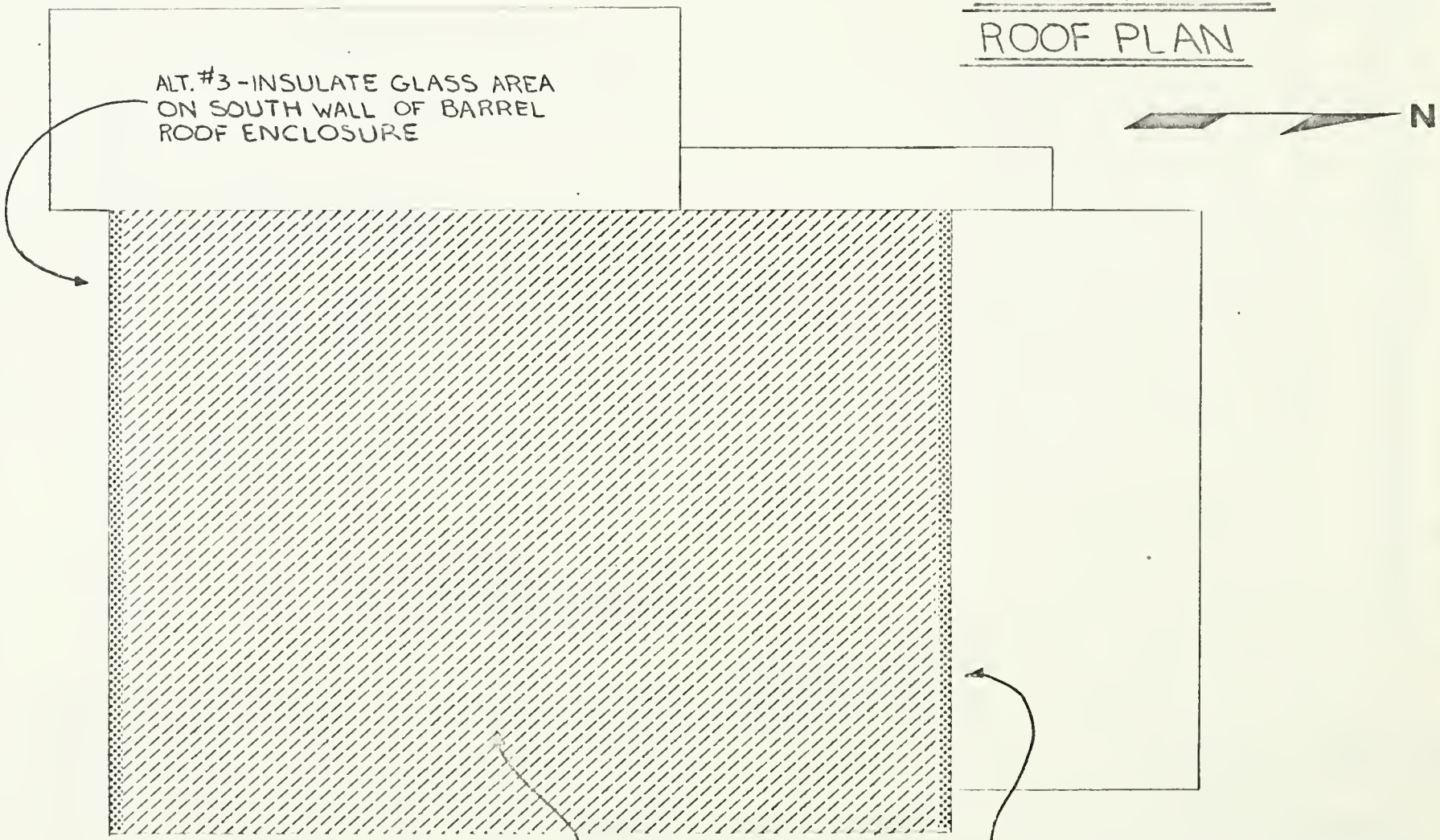
U. OF MONT. FIELD HOUSE
MASTER FLOOR PLAN
MISSOULA, MONTANA

DRAPES ENGINEERING
MECHANICAL & ELECTRICAL ENGINEERS
GREAT FALLS, MONTANA

DATE
SHEET
OF

7.175

# UNIVERSITY OF MONTANA
## FIELD HOUSE
## ROOF PLAN


ALT. #3 - INSULATE GLASS AREA ON SOUTH WALL OF BARREL ROOF ENCLOSURE
N
ALT. #2 - REINSULATE INSIDE OF BARREL ROOF.
ALT. #4 - INSULATE NORTH WALL OF BARREL ROOF ENCLOSURE WITH 10" BEADBOARD ON INSIDE.

U. OF MONT. FIELD HOUSE
ROOF PLAN
MISSOULA, MONTANA

DRAPES ENGINEERING
MECHANICAL & ELECTRICAL ENGINEERS
GREAT FALLS, MONTANA

DATE
SHEET
OF

7.176

TABLE 7.18

LIFE CYCLE COST SUMMARY

UNIVERSITY OF MONTANA FIELD HOUSE

| Alt. | Alternative Description | First Cost ($1000's) | Present Worth of Life Cycle Cost Savings ($1000's) | | Breakeven On First Cost (Yr) | | Percent Energy Savings | EUI BTU / GSF-DD |
|---|---|---|---|---|---|---|---|---|
| | | | Min. | Max. | Min. | Max. | | |
| 1 | Existing Building | - | - | - | - | - | - | 6.95 |
| 2 | Reinsulate Barrel Roof | 118 | 204 | 547 | 17 | 21 | 14.5 | 5.95 |
| 3 | Insulate glass on wall of barrel roof enclosure | 28 | 279 | 604 | 6 | 6 | 13.7 | 6.00 |
| 4 | Insulate wall of barrel roof enclosure | 21 | 92 | 211 | 10 | 12 | 5.0 | 6.60 |
| 5 | Block ticket office windows | 19 | 108 | 238 | 9 | 10 | 5.6 | 6.56 |
| 6 | Reinsulate ticket office ceiling | 6.8 | 39 | 86 | 9 | 10 | 2.0 | 6.81 |
| 7 | Insulate ticket office floor overhang | 1.5 | 8.0 | 18 | 9 | 10 | 0.4 | 6.92 |

3. LIFE CYCLE CONSERVATION RECOMMENDATIONS

a. The following alternatives, in order of priority, are recommended to conserve energy and reduce the Life Cycle owning and operating costs of the University of Montana Field House.

1. Alternative #3

Insulate glass on south wall of barrel roof enclosure. This provides an estimated energy savings of 13.7% for an investment of $27,640.00 with a payback of six years.

2. Alternative #5

Block up ticket office windows. This provides an estimated energy savings of 5.6% for an investment of $19,130.00 with a payback of 9 to 10 years (minimum to maximum).

3. Alternative #6

Reinsulate ticket office ceiling with ten-inch fiberglass batts. This provides an estimated energy savings of 2.0% for an investment of $6,750.00 with a payback of 9 to 10 years.

4. Alternative #7

Insulate ticket office floor overhang. This provides an estimated energy savings of 0.4% for an investment of $1,500.00 with a payback of 9 to 10 years.

5. Alternative #4

Insulate north wall of barrel roof enclosure. This provides an estimated energy savings of 5.0% for an investment of $21,000.00 with a payback of 10 to 12 years.

3. LIFE CYCLE CONSERVATION RECOMMENDATIONS

6. Alternative #2

Reinsulate the barrel roof. This provides an estimated energy savings of 14.5% for an investment of $120,000.00 with a payback of 17 to 21 years.

1. BUILDING DESCRIPTION

a. General

The Liberal Arts Building was constructed in 1952 for use as a classroom and office building. The classroom wing consists of three floors and a basement, and the office wing consists of four floors and a basement.

An addition was added in 1960 that approximately doubled the area of the building. The addition contains a three-floor classroom wing, a four-floor office wing and a two-floor, combination classroom-office wing. A small basement houses the mechanical and heating equipment.

b. Building Envelope

The roof of the original building is a flat concrete deck with wood crickets and a built-up roof to achieve proper drainage. There is no roof insulation.

The walls of the original building are brick and tile with no insulation.

The windows of the original building are single-pane glass set in aluminum frames. Some of the windows are loose fitting, resulting in drafts during cold weather.

The roof of the addition is a concrete deck with insulating concrete and a built-up roof to achieve drainage. The roof is insulated with 1" rigid roof insulation.

The walls of the addition are brick and tile, using a cavity wall construction. The cavity is insulated with vermiculite fill.

1. BUILDING DESCRIPTION (CONT'D)

The windows of the addition are single-pane glass set in aluminum frames. These windows are also loose fitting.

c. Heating and Ventilating System

The heating and ventilating system in the original building is a steam system fed from the central heating plant. Terminal heating units consist of unit ventilators controlled by wall thermostats in the classroom wing and fin tube controlled by two zone thermostats and hand valves in the offices.

The heating and ventilating system in the addition is a hot water system using a steam-to-water converter supplied with steam from the central heating plant. Terminal heating consists of unit ventilators controlled by wall thermostats in the classrooms and fin tube controlled by two zone thermostats per floor in the offices. This portion of the building has an automatic night setback system.

2. LIFE CYCLE ENERGY ANALYSIS

a. Description of Alternatives

The following alternatives were investigated for achieving energy conservation.

Alternative #1

This alternative is the existing building "as is". Alternative #1 is used as the basis for comparison against subsequent alternatives. A maintenance cost for changing burned out lamps is included in this alternative and all other alternatives, except Alternative #4. Since Alternative #4 requires a lower maintenance cost than the other alternatives, the difference in annual costs is added to all other alternatives.

Alternative #2

Retrofit the existing heating and ventilating system in the original building. This involves renovating the existing unit ventilators to operate on recommended minimum fresh air amounts; replace the existing wall thermostats controlling the unit ventilators with new thermostats capable of night setback operation; and install new wall thermostats capable of night setback operation and control valves for the fin tube in the office wing. Approximately four offices would be zoned on one thermostat. The automatic night setback system for this area is to be controlled by the campus automation system.

Alternative #3

Retrofit the existing heating and ventilating system in the addition. This includes renovating the existing unit ventilators to operate on recommended minimum fresh air amounts; replace the existing wall thermostats controlling the unit ventilators and fin tube with new thermostats

2. LIFE CYCLE ENERGY ANALYSIS (CONT'D)

capable of night setback operation; and renovate the existing night setback system.

Alternative #4

Replace the incandescent lighting in the classrooms and offices of the original building with fluorescent lighting. The life cycle cost calculations are based on a 70-foot candle lighting level for the fluorescent lighting. In addition to the reduction in energy use, the fluorescent lamps are rated with longer life times than the incandescent lamps. This results in a net annual maintenance savings based on lamp costs, lamp life, and replacement time. See Alternative #1 for incorporation of this economic factor.

Alternative #5

Remove all existing single-glazed windows in the original building and replace with double-glazed insulating glass.

Alternative #6

Remove all single-glazed windows in the original building and block-up with face brick and furring with insulation. Approximately 10% of the blocked-up area would remain as insulating glass.

Alternative #7

Remove all single-glazed windows in the addition and replace with double-glazed insulation glass.

Alternative #8

Remove all single-glazed windows in the addition and block-up with face brick and furring with insulation. Approximately 10% of the blocked-up area would remain as insulating glass.

2. LIFE CYCLE ENERGY ANALYSIS (CONT'D)

Alternative #9

Add 14" of blown-in insulation in the ceilings of the classrooms, and 14" of blown-in insulation and a new lay-in ceiling in the offices of the original building.

Alternative #10

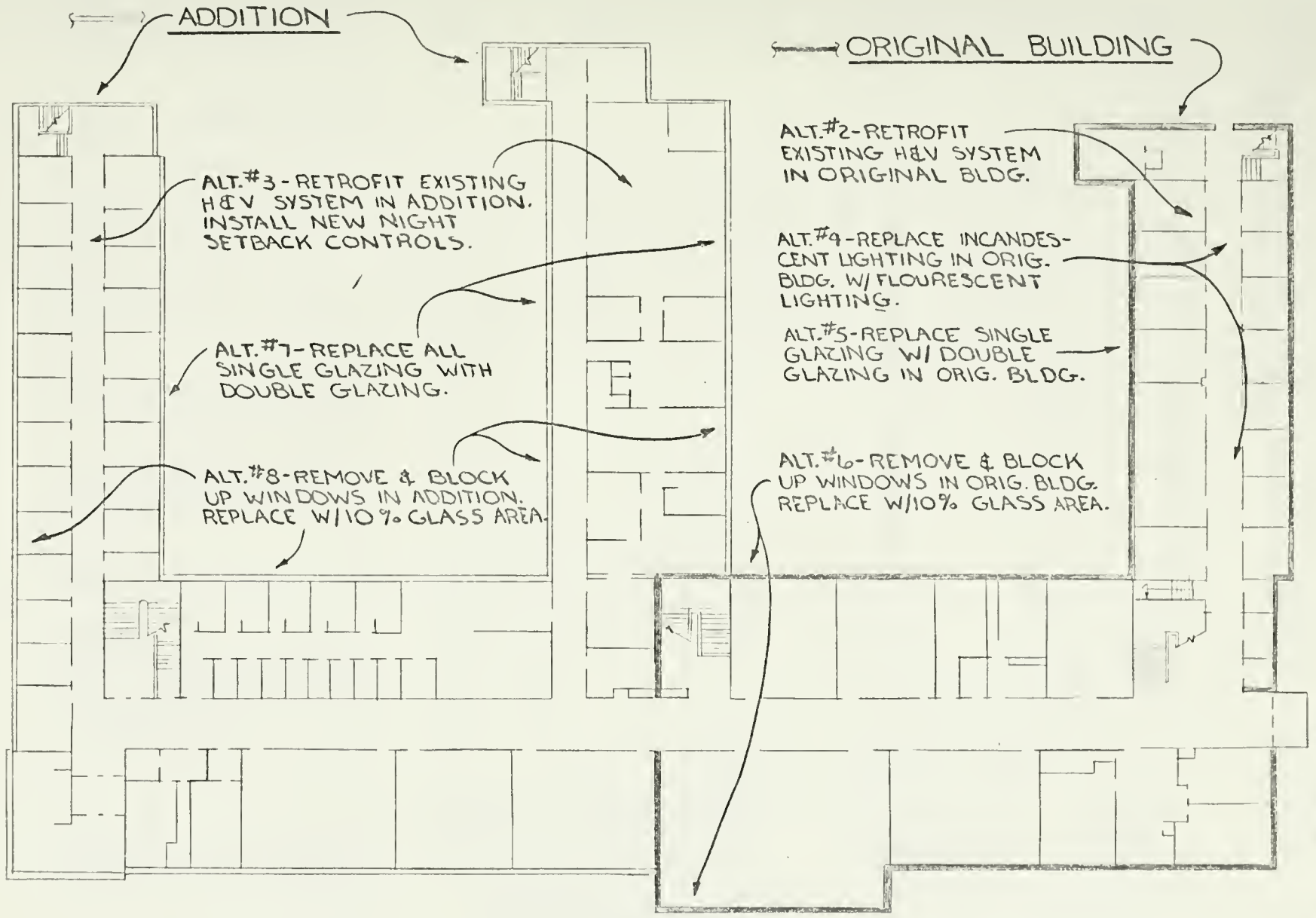
Add 12" of loose fill blown-in insulation in the lay-in ceiling of the classrooms and 12" of loose fill blown-in insulation and new lay-in ceiling in the offices of the addition.

Alternative #11

Insulate the exterior walls on the exterior surface with six inches of beadboard covered with one inch of stucco.

b. Life Cycle Cost Summary

Table 7.19 is a summary of the life cycle cost analysis of each alternative showing the estimated first cost, the present worth of life cycle cost savings, the breakeven point or payback of first cost in years, the percent energy savings, and the energy consumption in Btu/gross square foot of building area/degree day of each alternative.


ADDITION
ORIGINAL BUILDING
ALT.#2-RETROFIT EXISTING H&V SYSTEM IN ORIGINAL BLDG.
ALT.#3-RETROFIT EXISTING H&V SYSTEM IN ADDITION. INSTALL NEW NIGHT SETBACK CONTROLS.
ALT.#4-REPLACE INCANDESCENT LIGHTING IN ORIG. BLDG. W/ FLOURESCENT LIGHTING.
ALT.#5-REPLACE SINGLE GLAZING W/ DOUBLE GLAZING IN ORIG. BLDG.
ALT.#7-REPLACE ALL SINGLE GLAZING WITH DOUBLE GLAZING.
ALT.#8-REMOVE & BLOCK UP WINDOWS IN ADDITION. REPLACE W/10% GLASS AREA.
ALT.#6-REMOVE & BLOCK UP WINDOWS IN ORIG. BLDG. REPLACE W/10% GLASS AREA.
N

# LIBERAL ARTS BUILDING - FIRST FLOOR PLAN

LIBERAL ARTS BUILDING
UNIVERSITY OF MONTANA
MISSOULA, MONTANA

DRAPES ENGINEERING
MECHANICAL & ELECTRICAL ENGINEERS
GREAT FALLS, MONTANA

DATE 12-12-73
SHEET
OF

7.185

TABLE 7.19

LIFE CYCLE COST SUMMARY

U OF M LIBERAL ARTS BUILDING

| Alt. | Alternative Description | First Cost ($1000's) | Present Worth of Life Cycle Cost Savings ($1000's) | | Breakeven On First Cost (Yr) | | Percent Energy Savings | EUI BTU/GSF-DD |
|---|---|---|---|---|---|---|---|---|
| | | | Min. | Max. | Min. | Max. | | |
| 1 | Existing Building | - | - | - | - | - | - | 12.77 |
| 2 | Retrofit H&V system in original building and add night setback | 36 | 152 | 311 | 9 | 10 | 10.2 | 11.47 |
| 3 | Retrofit H&V system in addition | 24 | 130 | 260 | 8 | 9 | 8.3 | 11.71 |
| 4 | Replace incandescent lighting in original building with fluorescent lighting | 54 | 182 | 469 | 8 | 9 | 9.0 | 11.62 |
| 5 | Replace windows in original building with insulating glass | 192 | 159 | 457 | 20 | 25 | 19.0 | 10.34 |
| 6 | Block-up windows in original building | 113 | 473 | 970 | 10 | 10 | 31.7 | 8.72 |
| 7 | Replace windows in addition with insulating glass | 196 | 136 | 417 | 21 | 27 | 17.9 | 10.48 |
| 8 | Block-up windows in addition | 115 | 474 | 973 | 10 | 11 | 31.8 | 8.70 |
| 9 | Add 14" of blown-in ceiling insulation in original bldg. | 25 | 24 | 65 | 20 | 24 | 2.7 | 12.43 |
| 10 | Add 12" of blown-in ceiling insulation in addition | 33 | 15 | 55 | 24 | 30 | 2.6 | 12.44 |
| 11 | Insulate exterior walls with 6" beadboard & stucco | 119 | 119 | 321 | 19 | 24 | 12.9 | 11.12 |

3. LIFE CYCLE CONSERVATION RECOMMENDATIONS

a. The following alternatives, in order of priority, are recommended to conserve energy and reduce the Life Cycle owning and operating costs of the University of Montana Liberal Arts Building.

1. Alternative #3

Retrofit H&V system in addition. This provides an estimated energy savings of 8.3% for an investment of $24,000.00 with a payback of eight to nine years (minimum to maximum).

2. Alternative #4

Replace incandescent lighting in original building with fluorescent lighting. This provides an estimated energy savings of 9.0% for an investment of $54,000.00 with a payback of eight to nine years.

3. Alternative #2

Retrofit H&V system in original building and add night setback. This provides an estimated energy savings of 10.2% for an investment of $36,000.00 with a payback of nine to ten years.

4. Alternative #6

Block up windows in the original building. This provides an estimated energy savings of 31.7% for an investment of $113,000.00 with a payback of ten years.

5. Alternative #8

Block up windows in the addition. This provides an estimated energy savings of 31.8% for an investment of $115,000.00 with a payback of ten to eleven years.

3. LIFE CYCLE CONSERVATION RECOMMENDATIONS (CONT'D)

6. Alternative #11

Insulate exterior walls with 6" of beadboard covered with a stucco exterior. This provides an estimated energy savings of 12.9% for an investment of $119,000.00 with a payback of 19 to 24 years.

7. Alternative #9

Add 14" of blown-in ceiling insulation in original building. This provides an estimated energy savings of 2.7% for an investment of $25,000.00 with a payback of 20 to 24 years.

8. Alternative #5

Replace windows in the original building with insulating glass. This provides an estimated energy savings of 19.0% for an investment of $192,000.00 with a payback of 20 to 25 years.

9. Alternative #7

Replace windows in the addition with insulating glass. This provides an estimated energy savings of 17.9% for an investment of $196,000.00 with a payback of 21 to 27 years.

10. Alternative #10

Add 12" of blown-in ceiling insulation in addition. This provides an estimated energy savings of 2.6% for an investment of $33,000.00 with a payback of 24 to 30 years.

1. BUILDING DESCRIPTION

a. General

The pool building was constructed in 1957 and consists of a total of 22,630 square feet of floor space. The enclosed pool covers a floor area of 52 feet by 76 feet. The west side of the building encloses a hallway, locker rooms and office space. The space above this section holds the bleachers above the pool level. The entire building is covered with a barrel roof running in an east-west line.

The west edge of the pool building is adjoined by the art annex, which is treated as a separate building for the purposes of this report.

b. Building Envelope

The north and south walls are twelve feet high concrete block units with no insulation. The east wall consists of cellulose panels with no insulation. The west wall adjoins the art annex on the lower level. The upper level is separated from the art annex attic by an uninsulated panel wall. The barrel roof over the entire pool building is constructed of wood deck with one inch of rigid insulation and built-up roofing.

c. Heating, Ventilation and Air-Conditioning System

Heating and ventilating in the pool area is accomplished with two 18,000 cfm heating and ventilating units hung from the ceiling. There are also two 9,000 cfm exhaust fans serving the same area.

A separate heating and ventilating system serves the office/locker room area. Air is exhausted from this area through toilet room exhaust fans. A unit air conditioner is used in the office space.

2. LIFE CYCLE ENERGY ANALYSIS

a. Description of Alternatives

The following alternatives were investigated for achieving energy conservation.

Alternative #1

This alternative is the existing building "as is". Alternative #1 will be used as the basis for comparison against subsequent alternatives.

Alternative #2

Install sensing switches on the six garage doors which will not allow heating in the heating and ventilating steam heating coils when any of the doors are open.

Alternative #3

Install two heat recovery systems using the two sets of heating and ventilating units and exhaust fans. One heat recovery unit will be on each end of the building and the pairs of heating and ventilating units and exhaust fans will be interlocked.

Alternative #4

Install heat recovery units on the locker room exhaust fans.

Alternative #5

Insulate the garage doors with 1-1/2 inch preformed beadboard panels. Weatherstrip the garage doors.

Alternative #6

Insulate all exterior walls with 6-inch beadboard panels using an exterior stucco finish. Block up and cover over garage doors.

2. LIFE CYCLE ENERGY ANALYSIS (CONT'D)

Alternative #7

Insulate the wall separating pool area from the attic area over the art annex with six inches of unfinished beadboard.

Alternative #8

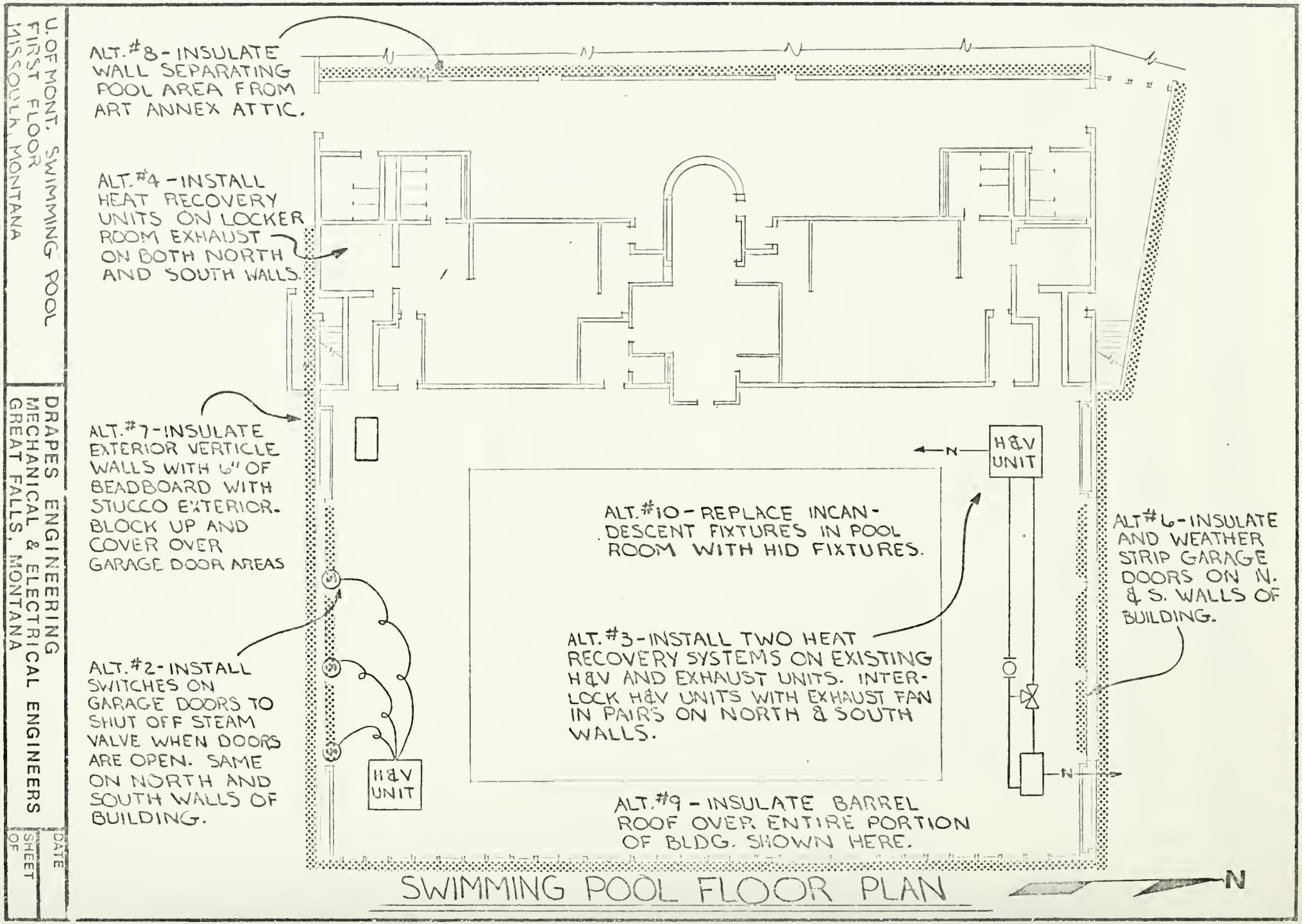
Insulate the barrel roof over the pool building using six inches of rigid insulation when the roof is to be replaced. Weatherproof with built-up roofing. Replace skylights with double layer skylights.

Alternative #9

Replace incandescent light fixtures over the pool area with HID lighting.

b. Life Cycle Cost Summary

Table 7.20 is the summary of the Life Cycle Cost Analysis of each alternative showing the estimated first cost, the present worth of life cycle cost savings, the breakeven point or payback of first cost in years, the percent energy savings, and the energy consumption in Btu/gross square foot of building area/degree day of each alternative.


U. OF MONT. SWIMMING POOL
FIRST FLOOR
MISSOULA, MONTANA
DRAPES ENGINEERING
MECHANICAL & ELECTRICAL ENGINEERS
GREAT FALLS, MONTANA
DATE
SHEET
OF
ALT.#8 - INSULATE WALL SEPARATING POOL AREA FROM ART ANNEX ATTIC.
ALT.#4 - INSTALL HEAT RECOVERY UNITS ON LOCKER ROOM EXHAUST ON BOTH NORTH AND SOUTH WALLS.
ALT.#7 - INSULATE EXTERIOR VERTICLE WALLS WITH 6" OF BEADBOARD WITH STUCCO EXTERIOR. BLOCK UP AND COVER OVER GARAGE DOOR AREAS
ALT.#2 - INSTALL SWITCHES ON GARAGE DOORS TO SHUT OFF STEAM VALVE WHEN DOORS ARE OPEN. SAME ON NORTH AND SOUTH WALLS OF BUILDING.
H&V UNIT
ALT.#10 - REPLACE INCANDESCENT FIXTURES IN POOL ROOM WITH HID FIXTURES.
ALT.#3 - INSTALL TWO HEAT RECOVERY SYSTEMS ON EXISTING H&V AND EXHAUST UNITS. INTERLOCK H&V UNITS WITH EXHAUST FAN IN PAIRS ON NORTH & SOUTH WALLS.
N
H&V UNIT
N
ALT.#6 - INSULATE AND WEATHER STRIP GARAGE DOORS ON N. & S. WALLS OF BUILDING.
ALT.#9 - INSULATE BARREL ROOF OVER ENTIRE PORTION OF BLDG. SHOWN HERE.
SWIMMING POOL FLOOR PLAN
N

7.192

TABLE 7.20

LIFE CYCLE COST SUMMARY

UNIVERSITY OF MONTANA POOL BUILDING

| Alt. | Alternative Description | First Cost ($1000's) | Present Worth of Life Cycle Cost Savings ($1000's) | | Breakeven On First Cost (Yr) | | Percent Energy Savings | EUI BTU/GSF-DD |
|---|---|---|---|---|---|---|---|---|
| | | | Min. | Max. | Min. | Max. | | |
| 1 | Existing Building | - | - | - | - | - | - | 34.98 |
| 2 | Install sensing switches on garage doors. | 1.6 | 64 | 111 | 2 | 2 | 6.1 | 32.84 |
| 3 | Install heat recovery system in pool area. | 28 | 382 | 679 | 3 | 4 | 38.6 | 21.49 |
| 4 | Install heat recovery units on locker room exhaust. | 5.6 | 36 | 64 | 6 | 7 | 3.8 | 33.64 |
| 5 | Insulate and weatherstrip garage doors. | 4.9 | 82 | 144 | 3 | 3 | 8.1 | 32.13 |
| 6 | Insulate all exterior walls. | 30 | 106 | 206 | 9 | 10 | 12.9 | 30.48 |
| 7 | Insulate west wall. | 6.4 | 26 | 49 | 8 | 9 | 3.0 | 33.93 |
| 8 | Reroof barrel roof. | 30 | 68 | 138 | 12 | 13 | 9.2 | 31.77 |
| 9 | Replace incandescent fixtures with HID lighting. | 9.4 | 41 | 88 | 6 | 7 | 2.4 | 34.12 |

3. LIFE CYCLE CONSERVATION RECOMMENDATIONS

a. The following alternatives, in order of priority, are recommended to conserve energy and reduce the Life Cycle owning and operating costs of the University of Montana Pool Building.

1. Alternative #2

Install sensing switches on all six garage doors which will shut off steam heating coils when the doors are open. This provides an estimated energy savings of 6.1% for an investment of $1,626.00 with a payback of two years.

2. Alternative #5

Insulate and weatherstrip the garage doors. This provides an estimated energy savings of 8.1% for an investment of $4,884.00 with a payback of three years.

3. Alternative #3

Install heat recovery units in the pool area. This provides an estimated energy savings of 38.6% for an investment of $27,873.00 with a payback of three to four years (minimum to maximum).

4. Alternative #4

Install heat recovery units on locker room exhaust fans. This provides an estimated energy savings of 3.8% for an investment of $5,646.00 with a payback of six to seven years.

5. Alternative #7

Insulate the wall separating the art annex attic from the pool area with 6-inch beadboard panels. This provides an estimated energy savings of 3.0% for an investment of $6,437.00 with a payback of eight to nine years.

3. LIFE CYCLE CONSERVATION RECOMMENDATIONS (CONT'D)

6. Alternative #9

Replace the incandescent light fixtures over the pool area with HID lighting. This provides an estimated energy savings of 2.4% for an investment of $9,391.00 with a payback of six to seven years.

7. Alternative #6

Insulate all exterior walls with six inches of beadboard insulation. Block up garage doors. Cover exterior with stucco finish. This provides an estimated energy savings of 12.9% for an investment of $29,978.00 with a payback of 9 to 10 years.

8. Alternative #8

Insulate the barrel roof over the pool area using six inches of rigid insulation when the roof is to be replaced. Double-glaze all skylights. This provides an estimated energy savings of 9.2% for an investment of $29,902.00 with a payback of 12 to 12 years.

1. BUILDING DESCRIPTION

a. General

The Lodge consists of three buildings built together on two levels. The first two of these, the Student Union and the Food Service buildings, were designed in 1954. The addition on the west end of the Food Service was designed in 1956. The Student Union Facility has 10,000 square feet per floor level and is presently used for office space on the first floor and the print shop on the second floor. The Food Service building has a kitchen on the lower floor with 12,700 square feet and a dining room on the upper floor with 13,000 square feet. The addition has 12,000 square feet of office space on the top floor and 15,600 square feet of additional dining space on the first floor.

b. Building Envelope

The north elevation of The Lodge has a consistent appearance on all three buildings. The lower level has a stone front on 4" concrete block walls. The upper level has 4" cedar puncheons with plywood and larch board interior construction. All glazing is double-glazed throughout. The south and east elevations have similar wall constructions, but without the stone fascia.

The addition has wood frame walls on the west and south elevations with 2" of blanket insulation and larch board exteriors. The lower level of the south wall on the addition has an 8" concrete block construction.

The roof is a tongue-in-groove wood deck with 1" of rigid insulation and built up roofing. The same roof construction is used throughout The Lodge.

1. BUILDING DESCRIPTION (CONT'D)

c. Heating, Ventilating and Air-Conditioning System

The Student Union part of the Lodge has a four-pipe fan coil heating and cooling system on both floors. The cooling is provided by a steam absorption chiller and the heating is provided by the central steam system on the campus.

The kitchen on the lower floor of the Food Service section uses two large ventilating systems with make up heaters. The kitchen also has a 25,000 cfm exhaust fan with no make up air or make up heater. An air handling unit behind the kitchen provides heating and ventilating in the office space in the Food Service section. The dining room above the kitchen has unit ventilators along the north and south walls.

The dining room on the first floor of the addition has unit ventilators along the west and south walls and four air handlers for the central area. The registrar's office area, on the second floor of the addition is served by a multizone unit.

2. LIFE CYCLE ENERGY ANALYSIS

a. Description of Alternatives

The following alternatives were investigated for achieving energy conservation.

Alternative #1

This alternative is the existing building "as is". Alternative #1 will be used as the basis for comparison against subsequent alternatives.

Alternative #2

Replace the 120-ton steam absorption chiller with an electric centrifugal chiller. Reuse the existing pumps where possible and reuse the cooling tower.

Alternative #3

Convert the multizone unit in the addition to a variable air volume system.

Alternative #4

Reinsulate the 1550-gallon domestic hot water tank located in the mechanical room below the kitchen. Add 6" of insulation to the existing insulation.

Alternative #5

Replace the 1550-gallon domestic hot water heater with a semi-instantaneous water heater to reduce the standby heat losses.

Alternative #6

Install a heat recovery system in the kitchen. Use a perimeter heat recovery loop with two cooling coils and two heating coils.

2. LIFE CYCLE ENERGY ANALYSIS (CONT'D)

Alternative #7

Install a makeup air heating unit with a heat recovery system on the existing 25,000 cfm exhaust hood over the grille in the kitchen.

Alternative #8

Cover the glass areas indicated in the drawings with a reflective surface on the inside of the glass. Glue 8" of beadboard insulation to this surface, then finish to match the building interior.

Alternative #9

Insulate the west wall with 4" of exterior beadboard insulation. Cover exterior with stucco.

Alternative #10

Insulate the south wall of the addition over concrete areas on the lower level. Apply 6" of beadboard on the exterior. Cover exterior with stucco.

Alternative #11

Install vestibules on the north side of the Student Union and the Food Service buildings.

Alternative #12

Insulate the entire roof with 6" of beadboard insulation. This alternative is to be applied when the roof needs replacement at its normal replacement time.

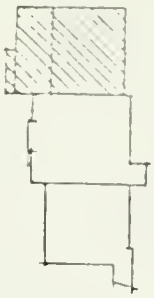
b. Life Cycle Cost Summary

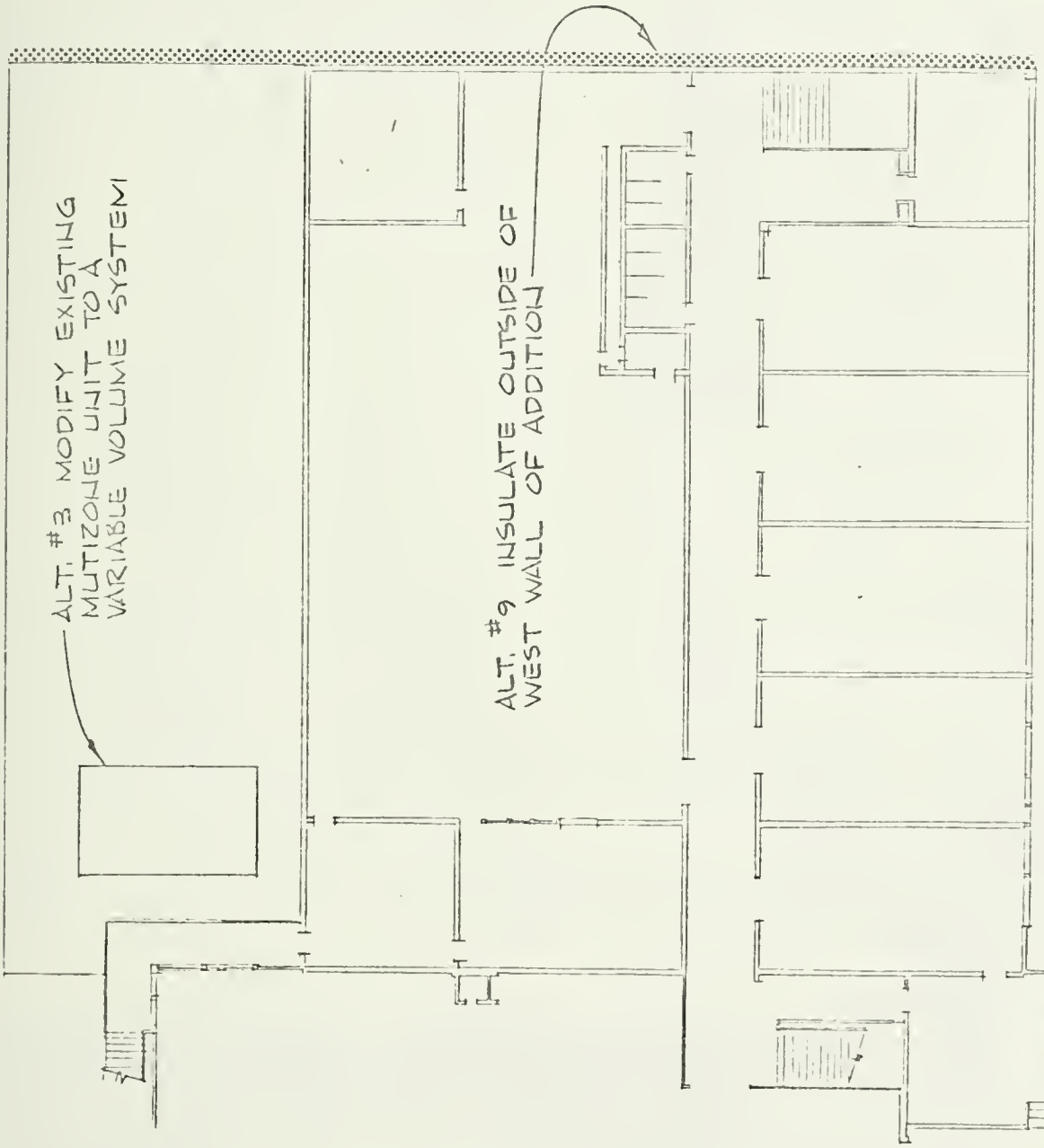
Table 7.2lis a summary of the Life Cycle Cost Analysis of each alternative showing the estimated first cost, the present worth of life cycle

2. LIFE CYCLE ENERGY ANALYSIS (CONT'D)

cost savings, the breakeven point or payback of first cost in years, the percent energy savings, and the energy consumption in Btu/gross square foot of building area/degree day of each alternative.

# THE LODGE - ADDITION
# UNIVERSITY OF MONTANA
# MISSOULA, MONTANA



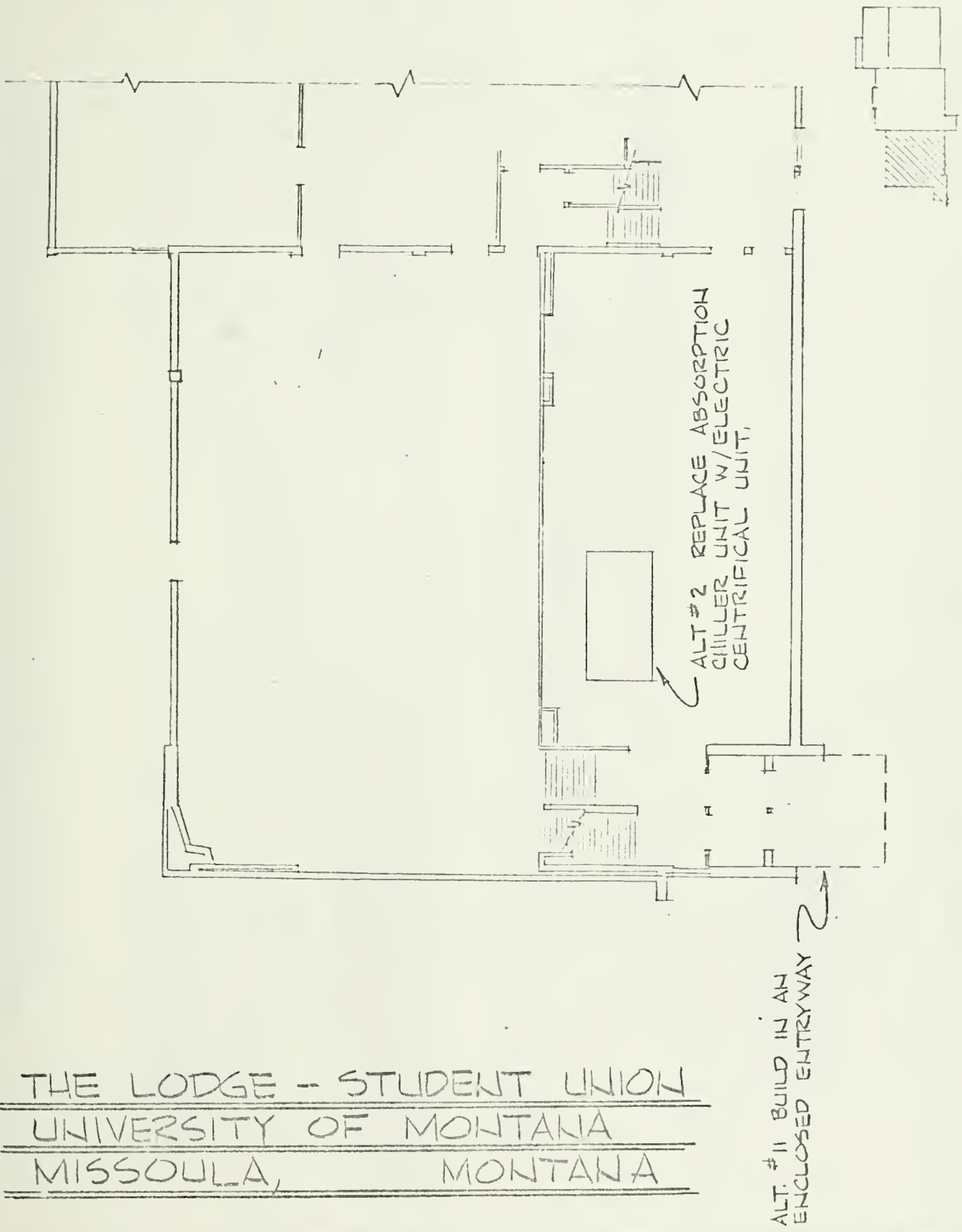



| | | |
|---|---|---|
| THE LODGE - ADDITION<br>UNIVERSITY OF MONTANA<br>MISSOULA, MONTANA | DRAPES ENGINEERING<br>MECHANICAL & ELECTRICAL ENGINEERS<br>GREAT FALLS, MONTANA | DATE<br>SHEET<br>OF |

N
ALT. #5 REPLACE D.H.W. TANK W/SEMI-INSTANTANEOUS HEATER
ALT. #4 REINSULATE EXISTING 1550 GAL. D.H.W. TANK
ALT#7 INSTALL A MAKE-UP AIR UNIT W/HEAT RECOVERY ON THE 25,000 CFM EXHAUST FAN OVER THE GRILLE IN THE KITCHEN
ALT. #11 BUILD IN THE SPACE UNDER THE UPPER LEVEL OVERHANG TO ENCLOSE THE CONCOURSE ENTRYWAY.
ALT. #6 INSTALL PERIMETER HEAT RECOVERY SYSTEM ON KITCHEN SUPPLY & EXHAUST AIR

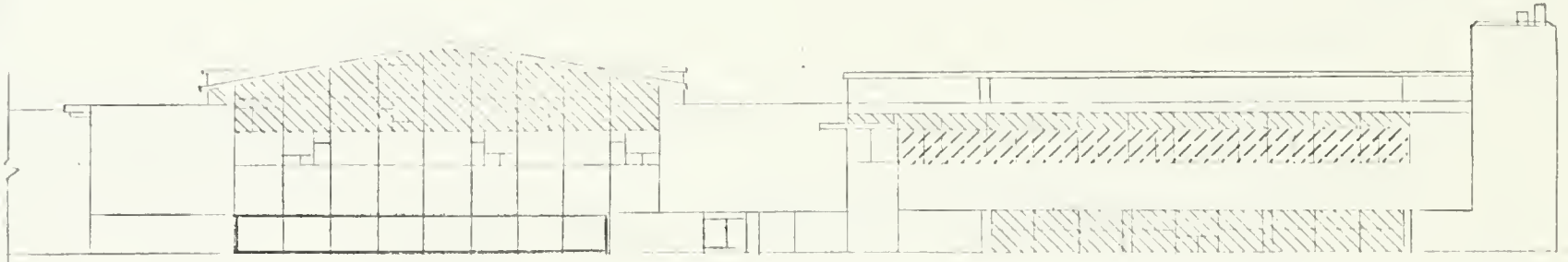
# THE LODGE - FOOD SERVICE
# UNIVERSITY OF MONTANA
# MISSOULA, MONTANA

| | | |
|---|---|---|
| THE LODGE- FOOD SERVICE<br>UNIVERSITY OF MONTANA<br>MISSOULA, MONTANA | DRAPES ENGINEERING<br>MECHANICAL & ELECTRICAL ENGINEERS<br>GREAT FALLS, MONTANA | DATE<br>SHEET<br>OF |



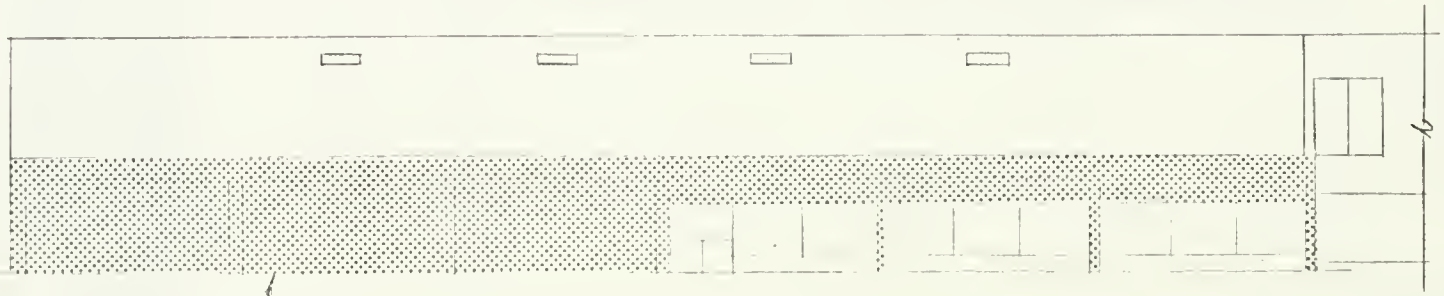

# THE LODGE - STUDENT UNION
# UNIVERSITY OF MONTANA
# MISSOULA, MONTANA

| | | |
|---|---|---|
| THE LODGE - STUDENT UNION<br>UNIVERSITY OF MONTANA<br>MISSOULA, MONTANA | DRAPES ENGINEERING<br>MECHANICAL & ELECTRICAL ENGINEERS<br>GREAT FALLS, MONTANA | DATE<br>SHEET<br>OF |



ALT. #8 COVER GLASS W/REFLECTIVE SURFACE ON INSIDE, GLUE ON BEADBOARD INSULATION ON INSIDE, FINISH INTERIOR TO MATCH EXISTING.

KEY: COVER 100% OF GLASS AREA
COVER 50% OF GLASS AREA



ALT #10 APPLY EXTERIOR BEADBOARD INSULATION TO CONCRETE SURFACES AS INDICATED.

NOTE:
ELEVATIONS NOT DRAWN TO SAME SCALE.

# SOUTH ELEVATION - THE LODGE
# UNIVERSITY OF MONTANA

THE LODGE - SOUTH ELEV.
UNIVERSITY OF MONTANA
MISSOULA, MONTANA

DRAPES ENGINEERING
MECHANICAL & ELECTRICAL ENGINEERS
GREAT FALLS, MONTANA

DATE
SHEET
OF

7.204

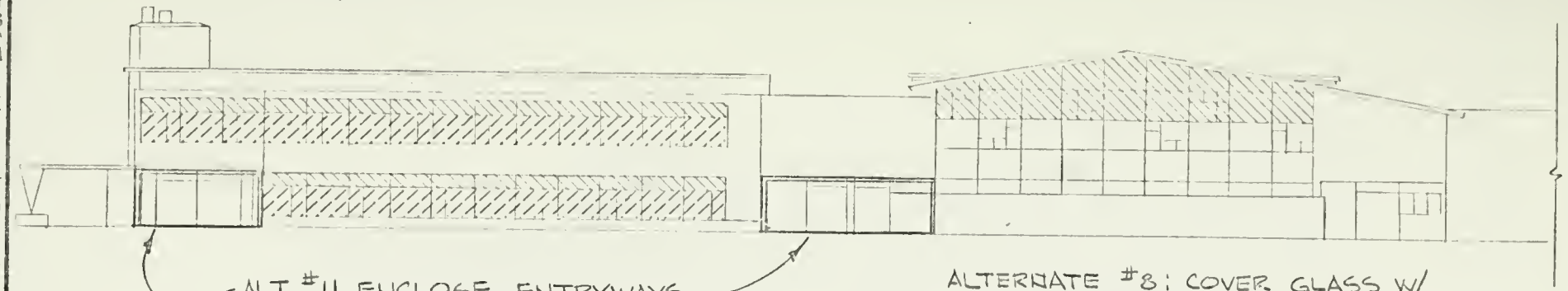
THE LODGE - NORTH ELEV.
UNIVERSITY OF MONTANA
MISSOULA, MONTANA

DRAPES ENGINEERING
MECHANICAL & ELECTRICAL ENGINEERS
GREAT FALLS, MONTANA

DATE

SHEET
OF

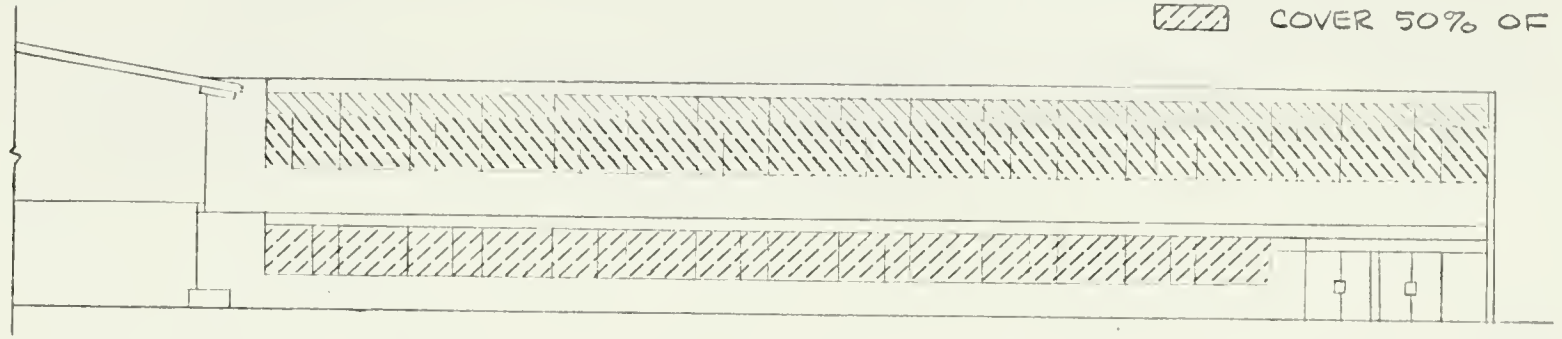
7.205



ALT. #11 ENCLOSE ENTRYWAYS TO MAKE VESTIBULES

ALTERNATE #8: COVER GLASS W/ REFLECTIVE SURFACE ON INSIDE, GLUE ON BEADBOARD INSULATION, FINISH INTERIOR TO MATCH EXISTING

KEY: COVER 100% OF GLASS AREA
COVER 50% OF GLASS AREA



NOTE:
ELEVATIONS NOT DRAWN TO SAME SCALE

# NORTH ELEVATION - THE LODGE

# UNIVERSITY OF MONTANA

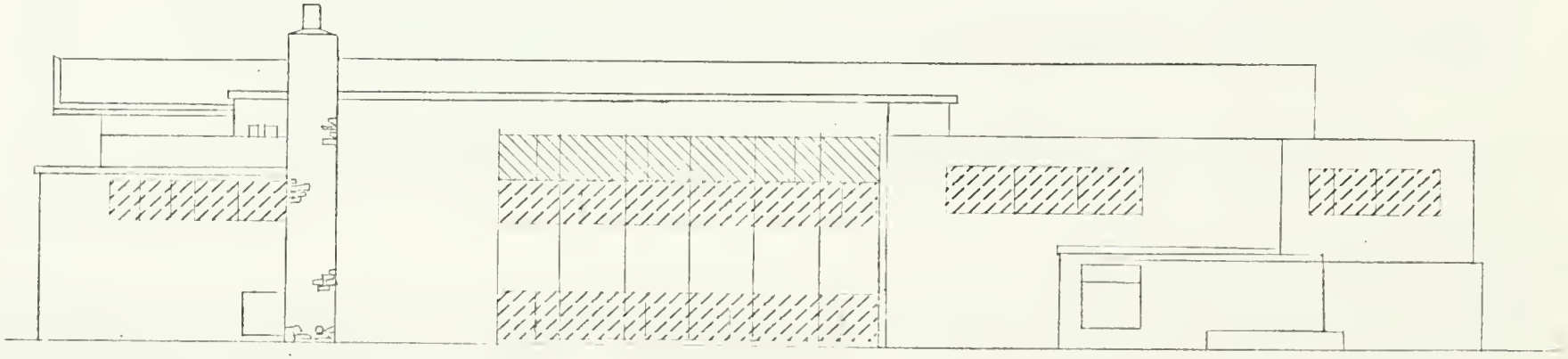
THE LODGE - EAST ELEV.
UNIVERSITY OF MONTANA
MISSOULA, MONTANA

DRAPES ENGINEERING
MECHANICAL & ELECTRICAL ENGINEERS
GREAT FALLS, MONTANA

DATE

SHEET
OF

7.206



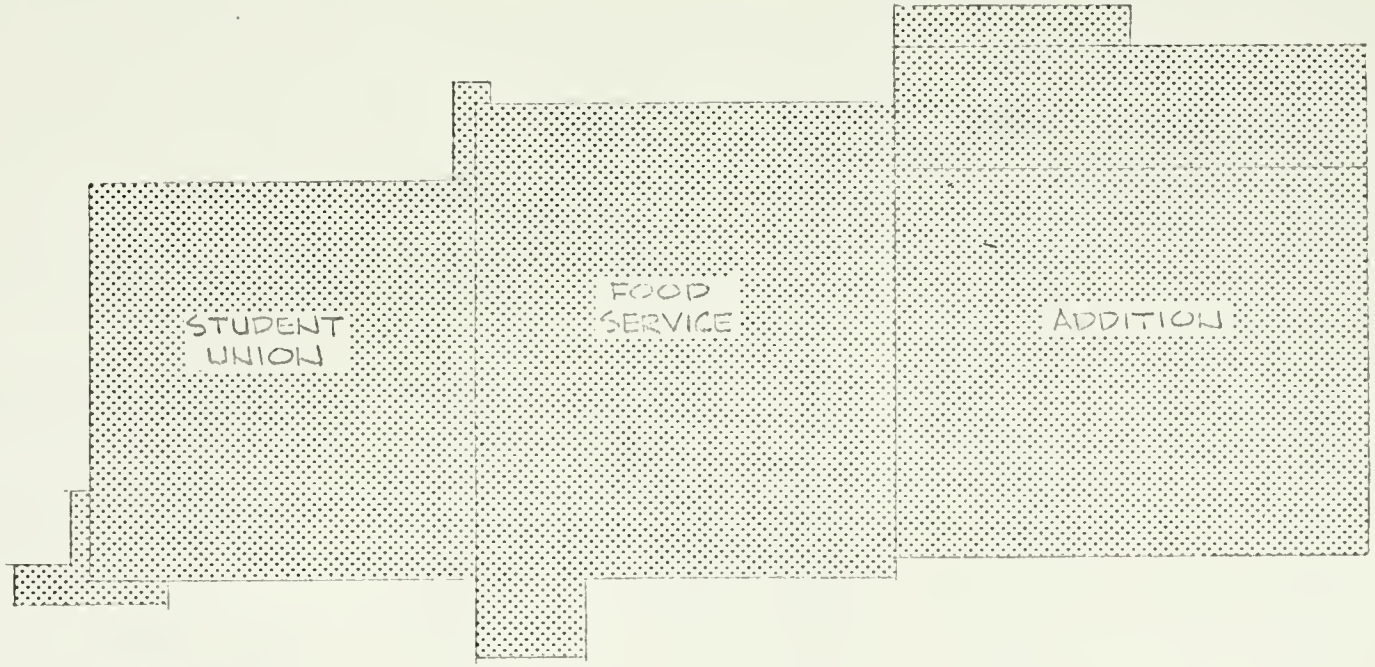
ALT #8: COVER GLASS W/REFLECTIVE SURFACE ON INSIDE, GLUE ON BEADBOARD INSULATION, FINISH INTERIOR TO MATCH EXIST.

KEY: COVER 100% OF GLASS AREA
COVER 50% OF GLASS AREA

# EAST ELEVATION - THE LODGE

# UNIVERSITY OF MONTANA

ALT. # 12: INSULATE ENTIRE ROOF AREA OF THE LODGE




# THE LODGE

# UNIVERSITY OF MONTANA

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THE LODGE
UNIVERSITY OF MONTANA
MISSOULA, MONTANA

DRAPES ENGINEERING
MECHANICAL & ELECTRICAL ENGINEERS
GREAT FALLS, MONTANA

DATE

SHEET
OF

7.207

TABLE 7.21

LIFE CYCLE COST SUMMARY

UNIVERSITY OF MONTANA - THE LODGE

| Alt. | Alternative Description | First Cost ($1000's) | Present Worth of Life Cycle Cost Savings ($1000's) | | Breakeven On First Cost (Yr) | | Percent Energy Savings | EUI BTU / GSF-DD |
|---|---|---|---|---|---|---|---|---|
| | | | Min. | Max. | Min. | Max. | | |
| 1 | Existing Building | - | - | - | - | - | - | 13.02 |
| 2 | Replace absorption chiller w/electric centrifugal | 56 | 95 | 144 | 16 | 17 | 12.2 | 11.44 |
| 3 | Modify multizone to VAV | 25 | 62 | 147 | 10 | 12 | 6.7 | 12.16 |
| 4 | Reinsulate DHW tank | 1.0 | 3.8 | 7 | 9 | 10 | 0.3 | 12.98 |
| 5 | Replace DHW tank w/semi-instantaneous heater | 4.0 | 1.4 | 5 | 22 | 28 | 0.4 | 12.98 |
| 6 | Install heat recovery in existing kitchen system | 19 | 58 | 133 | 9 | 10 | 5.9 | 12.26 |
| 7 | Install makeup unit with heat recovery on exhaust hood over grille in kitchen | 19 | 94 | 172 | 7 | 8 | 7.5 | 12.05 |
| 8 | Insulate glass on inside | 14 | 164 | 334 | 4 | 4 | 13.4 | 11.28 |
| 9 | Insulate west wall of addition | 9.0 | -3.3 | 2 | 32 | >35 | 0.4 | 12.96 |
| 10 | Insulate south wall of addition | 4.2 | 2.8 | 9 | 18 | 23 | 0.5 | 12.95 |
| 11 | Install 3 vestibules on north side of Lodge | 9.1 | 1.8 | 12 | 22 | 31 | 0.8 | 12.91 |
| 12 | Insulate roof on outside | 60 | 105 | 263 | 12 | 15 | 12.5 | 11.40 |

3. LIFE CYCLE CONSERVATION RECOMMENDATIONS

a. The following alternatives, in order of priority, are recommended to conserve energy and reduce the Life Cycle owning and operating costs of the University of Montana - Lodge.

1. Alternative #8

Insulate glass on the inside with 8" of beadboard. This provides an estimated energy savings of 13.4% for an investment of $13,500.00 with a payback of four years.

2. Alternative #7

Install makeup air vent with heat recovery on large exhaust hood over grille in kitchen. This provides an estimated energy savings of 7.5% for an investment of $18,600.00 with a payback of seven to eight years (minimum to maximum).

3. Alternative #4

Reinsulate the domestic hot water tank. This provides an estimated energy savings of 0.3% for an investment of $1,000.00 with a payback of 9 to 10 years.

4. Alternative #6

Install heat recovery in the existing kitchen H&V system. This provides an estimated energy savings of 5.9% for an investment of $19,200.00 with a payback of 9 to ten years.

5. Alternative #3

Modify the existing multizone system in the registrar's office area to operate as a variable air volume system. This provides an estimated energy savings of 6.7% for an investment of $25,400.00 with a payback of 10 to 12 years.

3. LIFE CYCLE CONSERVATION RECOMMENDATIONS (CONT'D)

6. Alternative #12

Insulate the roof on the outside with 6" of beadboard. This provides an estimated energy savings of 12.5% for an investment of $60,000.00 with a payback of 12 to 15 years. (Note: This alternative is to be done when the existing roof is replaced.)

7. Alternative #2

Replace absorption chiller with an electric centrifugal chiller. This provides an estimated energy savings of 12.2% for an investment of $55,800.00 with a payback of 16 to 17 years.

8. Alternative #10

Insulate the south wall of the addition with 6" of rigid insulation on the exterior. This provides an estimated energy savings of 0.5% for an investment of $4,200.00 with a payback of 18 to 23 years.

9. Alternative #11

Install two vestibules on the north side of the Lodge. This provides an estimated energy savings of 0.8% for an investment of $9,100.00 with a payback of 22 to 31 years.

10. Alternative #9

Insulate the exterior of the west wall of the addition with 4" of rigid insulation. This provides an estimated energy savings of 0.4% for an investment of $9,000.00 with a payback of 32 years to a number exceeding the economic life of the building.

# APPENDIX 1

ENERGY CONSERVATION GUIDELINES FOR STATE-OWNED BUILDINGS

(Bound Separately)

# APPENDIX 2

BUILDINGS METERED BY DRAPES ENGINEERING
UNDER THE A/E 77-30-04 PROJECT

BOULDER RIVER SCHOOL AND HOSPITAL

- Boys Dormitory #7
- Cottage #3
- Cottage #5
- Girls Dormitory #6

CAPITOL COMPLEX

- Agriculture
- Board of Health
- Boiler Plant
- Capitol Building
- Cogswell Building
- Livestock Annex
- New Mitchell Building
- Old Mitchell Building
- Veterans Memorial Building

EASTERN MONTANA COLLEGE

- Liberal Arts
- Library Building
- McMullen Hall
- Special Education

EASTMONT TRAINING CENTER

- Multipurpose Center

GALEN

- Annex Hospital
- Kitchen, Crockett, and Terrill Wing
- Receiving Hospital

MONTANA STATE PRISON

- Maximum Security
- Rothe Hall
- Slaughter House

MONTANA STATE UNIVERSITY

- Cooley Lab
- Culbertson
- Gaines Hall
- Health Center
- Health & Physical Education Building

MONTANA STATE UNIVERSITY (CONT'D)

Heating Plant
Horticulture
McCall Hall
Pryor
Ryan Lab
Sherrick
Stadium
Student Union

MONTANA TECH

Library - Museum
Men's Residence Hall
Metallurgy

MONTANA VETERAN'S HOME

New Veteran's and Nursing Building

MOUNTAIN VIEW SCHOOL FOR GIRLS

Maple Cottage

NORTHERN MONTANA COLLEGE

Auto Mechanics
Cowan Hall
Gym Armory

PINE HILLS SCHOOL

Academic Training
Physical Training

SCHOOL FOR THE DEAF AND BLIND

Academic Facility

SWAN RIVER YOUTH CAMP

Food Service
Lodge

UNIVERSITY OF MONTANA

Business Administration Building
Chemistry - Pharmacy
Fine Arts
Forestry
Health Science
Journalism
Liberal Arts
Main Hall
Mathematics
Mens Gym
Music
Natural Science
Natural Science Addition
Psychology
Venture Center
Womens Center

WARM SPRINGS STATE HOSPITAL

Bolton
Receiving Hospital
Warren

WESTERN MONTANA COLLEGE

Auditorium and Shop
Gymnasium
Main Building
Old Library
Physical Education Building
Student Union

# APPENDIX 3

## COMPUTER PRINTOUT INTERPRETATION GUIDE

## Computer Printout Interpretation Guide

The following is intended as a guide in interpretation of the computer output from the Life Cycle Cost Economic Analysis Program.

A sample output has been used to show the comparisons of alternatives to demonstrate the Life Cycle Cost Analysis and its methodology.

Each page of the computer output has been illustrated and the terms itemized by a letter. An explanation of the itemized terms precedes each illustrated page.

Figure 3A.1:

Item A: Alternative Description

A description of the alternative to be evaluated.

Item B: Heating, Ventilating and Air-Conditioning System Description

A description of the heating, ventilating and air-conditioning system utilized with the alternative being evaluated.

Item C: Utility Type and Cost Schedule

A description of the utilities used by the alternative and their rate schedules.

Item D: Steam

A description of the utility.

Item E: Utility Units of MLB

A description of the consumption units of the utility. 'MCF' indicates thousands of cubic feet, 'KWH' indicates kilowatt hours, and 'MLB' indicates thousands of pounds.

Item F: Inflation Rate

This inflation rate is applied as an annual inflation to the utility rate.

Item G: Demand Charge

The charge for demand of the utility. For electricity, the charge is for each kilowatt of demand.

Item H: Rate

The rate in dollars per unit of utility consumption.

Item I: Cutoff

This is the block of utility consumption units the previous rate in Item H is applied to.

JOB DATA

ALTERNATIVE DESCRIPTION: A
INSTALL TEMP CONTROLS & NIGHT SETBACK

HEATING,VENTILATING & AIR CONDITIONING SYS. DESCRIPTION: B
HEATING SYSTEM - CONVECTORS & 2 H&V UNITS IN ATTIC
COOLING SYSTEM - NONE

UTILITY TYPE & COST SCHEDULE: C

STEAM D
UTILITY UNITS OF MLBS E
INFLATION RATE = 12.0 PERCENT F
DEMAND CHARGE = $ 0.000 G

| RATE | CUTOFF | RATE | CUTOFF | RATE | CUTOFF | RATE | CUTOFF | RATE | CUTOFF |
|---|---|---|---|---|---|---|---|---|---|
| 4.570 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 |

H
I

ELECTRIC
UTILITY UNITS OF KWH
INFLATION RATE = 7.0 PERCENT
DEMAND CHARGE = $ 1,880

| RATE | CUTOFF | RATE | CUTOFF | RATE | CUTOFF | RATE | CUTOFF | RATE | CUTOFF |
|---|---|---|---|---|---|---|---|---|---|
| .020 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 |

3A.3

FIGURE 3A.1

Figure 3A.2:

Item A: Alternative Description

A description of the alternative to be evaluated.

Item B: Economic Parameters

A summary of the economic parameters used to compute the Life Cycle Cost of the alternative.

Item C: First Cost

The total first cost of the alternative.

Item D: First Cost; Percent Financed

The percentage of the first cost financed by mortgage, bonds, etc.

Item E: First Cost; Equity; Amount

The amount of the first cost financed by the Owner's capital.

Item F: First Cost; Financed; Amount

The amount of the first cost financed by mortgage, bonds, etc.

Item G: First Cost; Financed; Mortgage Interest

The interest rate of the mortgage.

Item H: First Cost; Financed; Mortgage Life

The life of the mortgage.

Item I: Economic Life

The length in years of the economic life or life cycle of the alternative.

Item J: Salvage Value

The salvage value of the alternative to be applied to the Life Cycle Cost at the end of the life cycle.

Item K: Maintenance Cost; Amount

The annual maintenance cost of the alternative.

Item L: Maintenance Cost; Inflation Rate

The annual inflation rate applied to the maintenance cost.

Item M: Income Tax; Tax Rate

The total income tax rate paid by the Owner. This includes local, State and Federal income taxes.

Item N: Income Tax; Method of Depreciation

The method of depreciation applied to this alternative. 'SLD' indicates straight line depreciation and 'SYD' indicates sum of the years' digits depreciation.

Item O: Property Tax; Tax Rate

The property tax rate paid by the Owner. This rate is applied to the total first cost of the alternative.

Item P: Property Tax; Inflation Rate

The annual inflation rate applied to property taxes.

Item Q: Insurance; Insurance Rate

The insurance rate paid by the Owner. This rate is applied to the total first cost of the alternative.

Item R: Insurance; Inflation Rate

The annual inflation rate applied to the insurance costs.

Item S: Rate of Return

The Owner's minimum rate of return.

JOB DATA (CONTINUED)

ALTERNATIVE DESCRIPTION: (A)
INSTALL TEMP CONTROLS & NIGHT SETBACK

ECONOMIC PARAMETERS: (B)

| | | | |
|---|---|---|---|
| FIRST COST | = $ | 114790 | (C) |
| PERCENT FINANCED | = | 0.00 PERCENT | (D) |
| EQUITY | | | |
| AMOUNT | = $ | 114790 | (E) |
| FINANCED | | | |
| AMOUNT | = $ | 0 | (F) |
| MORTGAGE INTEREST | = | 0.00 PERCENT | (G) |
| MORTGAGE LIFE | = | 0 YEARS | (H) |
| ECONOMIC LIFE | = | 40 YEARS | (I) |
| SALVAGE VALUE | = $ | 0 | (J) |
| MAINTNANCE COST | | | |
| AMOUNT | = $ | 500 | (K) |
| INFLATION RATE | = | 6.00 PERCENT | (L) |
| INCOME TAX | | | |
| TAX RATE | = | 0.00 PERCENT | (M) |
| METHOD OF DEPRECIATION | = | | (N) |
| PROPERTY TAX | | | |
| TAX RATE | = | 0.00 PERCENT | (O) |
| INFLATION RATE | = | 0.00 PERCENT | (P) |
| INSURANCE | | | |
| INSURANCE RATE | = | 0.00 PERCENT | (Q) |
| INFLATION RATE | = | 0.00 PERCENT | (R) |
| RATE OF RETURN | = | 6.00 PERCENT | (S) |

3A.6

FIGURE 3A.2

Figure 3A.3:

Item A: Utility Consumption

A summary of the utility consumption of the alternative being evaluated. The consumption figures are calculated by the degree day method using average degree days supplied by the National Weather Service.

Item B: Utility

A description of the utilities used by the alternative.

Item C: Energy Units

A description of the utility consumption units.

Item D: Jan

A breakdown by month of the consumption of each utility.

Item E: Total

The total for the year of the consumption of each utility.

Item F: Total Energy Million BTU

The total by month in millions of Btu's of the energy consumption of the alternative.

Item G: The total annual energy consumption in millions of Btu's of the alternative.

Item H: Annual Energy Use

The total annual energy consumption of the alternative in units of Btu per gross square feet of building per year.

Item I: Utility Cost in 1978 Dollars

A summary of the utility costs of the alternative being evaluated in 1978 dollars.

Item J: Utility

A description of the utilities used by the alternative.

Item K: Jan

A breakdown by month of the cost of each utility.

Item L: Total

The total for the year of the cost of each utility.

Item M: Total Cost

The total by month of the cost of utilities.

Item N:

The total annual utility cost of the alternative.

A L T E R N A T I V E  2
INSTALL TEMP CONTROLS & NIGHT SETBACK

UTILITY CONSUMPTION

| UTILITY | ENERGY UNITS | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STEAM | MLBS | 1248 | 952 | 915 | 574 | 344 | 166 | 28 | 49 | 261 | 524 | 857 | 1109 | 7027 |
| ELECTRIC | KWH | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 2880 |
| DEMAND | KW | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| TOTAL ENERGY MILLION BTU | | 1248 | 952 | 915 | 575 | 345 | 167 | 29 | 50 | 262 | 525 | 858 | 1110 | 7037 |

ANNUAL ENERGY USE = 127021 BTU/SQ.FT./YR.



UTILITY COST IN 1978 DOLLARS

| UTILITY | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STEAM | 5701 | 4349 | 4180 | 2623 | 1572 | 761 | 129 | 224 | 1192 | 2396 | 3917 | 5070 | 32114 |
| ELECTRIC | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 81 |
| DEMAND COST | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 23 |
| TOTAL COST | 5710 | 4357 | 4189 | 2632 | 1581 | 769 | 138 | 232 | 1201 | 2404 | 3926 | 5079 | 32217 |

FIGURE 3A.3

Figure 3A.4:

Item A: Year

A breakdown of the owning and operating costs is given for each year in the Life Cycle of the Alternative.

Item B: Utility Cost

The utility cost per year is calculated using the appropriate inflation rate for each utility.

Item C: Maintenance Cost

The maintenance cost per year is calculated using the maintenance cost inflation rate.

Item D: Interest Cost

The interest cost per year on the remaining balance of the mortgage.

Item E: Principal Cost

The amount per year paid to the principal of the mortgage.

Item F: Property Taxes

The property tax cost per year is calculated using the property tax inflation rate.

Item G: Insurance Cost

The insurance cost per year is calculated using the insurance cost inflation rate.

Item H: Replacement Cost

If the life of the HVAC equipment or a portion of the building such as a roof is less than the life cycle of the alternative, then a replacement expenditure must be made within this period. This amount is shown as a lump sum amount for the year in which the expenditure occurs.

Item I: Depreciation

The depreciation expense per year is calculated using the appropriate method of depreciation specified previously. The length of time the alternative is depreciated over is taken as the life cycle of the alternative. Replacement expense (Item H) is also depreciated for the life cycle of the building and is added to the annual depreciation for the years following the year in which the replacement expense occured.

Item J: Equity Cost

The cost of the Owner's equity or capital funds is:

$$\text{Annual Equity Cost} = \text{Equity First Cost} \times \frac{i(1+i)^n}{(1+i)^n-1}$$

Where
i = Rate of Return
n = Life Cycle in Years

Item K: Owning and Operating Cost

The owning and operating cost per year is the sum of all the owning and operating costs for the year with the effect of income taxes and depreciation taken into account.

$$\text{Owning \& Operating Cost} = B + C + D + E + F + G + H + J - (B + C + D + F + G + I) \times (\text{Income Tax Rate})$$

Item L: Annual Owning and Operating Cost

The annualized owning and operating cost.

$$\text{Annual Owning \& Operating Cost} = \text{Present Worth of Life Cycle Cost} \times \frac{i(1+i)^n}{(1+i)^n-1}$$

Where
i = Rate of Return
n = Life Cycle in Years

Item M: Present Worth of Life Cycle Cost

The present worth of the sum of the yearly owning and operating costs. This is the total life cycle cost of the alternative discounted to the present worth of 1978 dollars.

$$\text{Present Worth of Life Cycle Cost} = \sum_{z=1}^{n} K_z \times \frac{1}{(1+i)^n}$$

Where
i = Rate of Return
n = Life Cycle in Years
K = Yearly Owning and Operating cost (Item K)
z = Year for which the Owning and Operating cost (Item K) is computed

EXISTING BUILDING

E C O N O M I C  P E R F O R M A N C E

| A | B | C | D | E | F | G | H | I | J | K |
|---|---|---|---|---|---|---|---|---|---|---|
| YEAR | UTILITY COST | MAINTENANCE COST | INTEREST COST | PRINCIPAL COST | PROPERTY TAXES | INSURANCE COST | REPLACEMENT COST | DEPRE-CIATION | EQUITY COST | OWNING & OPERATING COST |
| 31 | 162897 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 162897 |
| 32 | 181734 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 181734 |
| 33 | 202703 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 202703 |
| 34 | 226303 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 226303 |
| 35 | 252590 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 252590 |
| 36 | 281970 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 281970 |
| 37 | 314810 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 314810 |
| 38 | 351521 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 351521 |
| 39 | 392564 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 392564 |
| 40 | 438451 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 438451 |

ANNUAL OWNING AND OPERATING COST = $ 49890

PRESENT WORTH OF LIFE CYCLE COST = $ 750656

FIGURE 3A.4

Figure 3A.5:

Item A: Year

A breakdown of the owning and operating cost savings of Alternative 2 over Alternative 1 is given for each year in the life cycle of the alternative.

Item B: Utility Cost Savings

The utility cost savings of Alternative 2 over Alternative 1 after income taxes have been taken into account.

Item C: Operating Cost Savings

The savings in maintenance cost, property taxes, insurance cost, replacement cost and salvage value of Alternative 2 over Alternative 1 after income taxes have been taken into account.

Item D: Owning Cost Savings

The savings in interest cost, principal cost, and equity cost of Alternative 2 over Alternative 1 after income taxes and depreciation have been taken into account.

Item E: Owning and Operating Cost Savings

The total savings per year in owning and operating costs of Alternative 2 over Alternative 1 after income taxes and depreciation have been taken into account.

Owning & Operating Cost Savings = B + C + D

E C O N O M I C  C O M P A R I S O N

| A<br>YEAR | B<br>UTILITY COST SAVINGS | C<br>OPERATING COST SAVINGS | D<br>OWNING COST SAVINGS | E<br>OWNING & OPERATING COST SAVINGS |
|---|---|---|---|---|
| 1 | 719 | 0 | - 6669 | - 5950 |
| 2 | 806 | 0 | - 6669 | - 5864 |
| 3 | 903 | 0 | - 6669 | - 5767 |
| 4 | 1011 | 0 | - 6669 | - 5659 |
| 5 | 1132 | 0 | - 6669 | - 5537 |
| 6 | 1268 | 0 | - 6669 | - 5401 |
| 7 | 1420 | 0 | - 6669 | - 5249 |
| 8 | 1591 | 0 | - 6669 | - 5079 |
| 9 | 1781 | 0 | - 6669 | - 4888 |
| 10 | 1995 | 0 | - 6669 | - 4674 |
| 11 | 2235 | 0 | - 6669 | - 4435 |
| 12 | 2503 | 0 | - 6669 | - 4167 |
| 13 | 2803 | 0 | - 6669 | - 3866 |
| 14 | 3139 | 0 | - 6669 | - 3530 |
| 15 | 3516 | 0 | - 6669 | - 3153 |



FIGURE 3A.5

Figure 3A.6:

Item A: First Cost Difference

The difference in total first cost of Alternative 2 over Alternative 1.

Item B: Annual Owning and Operating Cost Savings

The annualized owning and operating cost savings of Alternative 2 over Alternative 1.

Annual Owning & Operating Cost Savings

$$\doteq \text{Present Worth of Life Cycle Cost Savings} \times \frac{i(1+i)^n}{(1+i)^n-1}$$

Where
i = Rate of Return
n = Life Cycle in Years

Item C: Present Worth of Life Cycle Cost Savings

The present worth of the sum of the yearly owning and operating cost savings (Item E, Figure 3A.5) This is the total life cycle cost savings of Alternative 2 over Alternative 1 discounted to the present worth of today's dollars.

$$\text{Present Worth of Life Cycle Cost Savings} = \sum_{z=1}^{n} E_z \times \frac{1}{(1+i)^n}$$

Where
i = Rate of Return
n = Life Cycle in Years
E = Yearly Owning & Operating Cost Savings (Item E, Figure 3A.5)
z = Year for which the Owning & Operating Cost (Item E, Figure 3A.5) is computed.

Item D: Break-even on First Cost

The number of years required to pay back the first cost difference (Item A) by utility and operating cost savings (Items B + C, Figure 3A.5)

Item E: Percent Energy Savings

The amount of energy in percent saved by Alternative 2 over Alternative 1

A L T E R N A T I V E  2  V S  A L T E R N A T I V E  1
INSTALL TEMP CONTROLS & NIGHT SETBACK  V S  EXISTING BLDG.

E C O N O M I C  C O M P A R I S O N

FIRST COST DIFFERENCE = $ - 114790 — A

ANNUAL OWNING AND OPERATING COST SAVINGS = $ 32726 — B

PRESENT WORTH OF LIFE CYCLE COST SAVINGS = $ 492412 — C

BREAKEVEN ON FIRST COST = 18 YEARS — D

PERCENT ENERGY SAVINGS = 12.7 — E

# APPENDIX 4

LIFE CYCLE COST ECONOMIC ANALYSIS BASED ON
MINIMUM AND MAXIMUM UTILITY RATES

(Bound Separately)

# APPENDIX 5

## SEVENTEEN BUILDING COMPLEX ENERGY AUDIT

# E N E R G Y  A U D I T  1973

FOR

ENERGY CONSERVATION STUDY

MONTANA

JANUARY 5, 1979

BY

DRAPES ENGINEERING
202 EKLUND BUILDING
GREAT FALLS, MONTANA

JOB NO. 77129

# DESCRIPTION OF OUTPUT LISTING

LOCATION: CITY NAME, (MONTANA ASSUMED AS THE STATE, UNLESS SPECIFIED OTHERWISE).

BUILDING TYPE: DESCRIBES MAJOR USE OF FACILITY.

BUILDING AREA: TOTAL AREA OF ALL FLOORS, IN GROSS SQUARE FEET (GSF).

HEATING DEGREE DAYS: ANNUAL TOTAL OF DIFFERENCE BETWEEN DAILY MEAN TEMP. AND 65 °F.

ENERGY CONSUMPTION: BASED ON UTILITY BILLING RECORDS.

GAS: AMOUNT USED DURING THE YEAR, IN THOUSANDS OF CUBIC FEET, (MCF).

ELECTRIC: AMOUNT USED DURING THE YEAR, INDICATED IN THOUSANDS OF KWH, (MKWH).

OTHER: ANY OTHER ENERGY SOURCE,LISTED BY ENERGY CONTENT IN MILLIONS OF BTU, (MMBTU).

TOTAL: AMOUNT OF ENERGY USED DURING AUDIT YEAR, IN MILLIONS OF BTU, (MMBTU).

USAGE OF ENERGY:

BTU/GSF-YR IS A PARAMETER PROVIDING A COMMON BASIS OF COMPARISON OF ENERGY USAGE FOR BUILDINGS HAVING SIMILAR CLIMATIC CONDITIONS. 'AVERAGE' VALUES OF THIS PARAMETER ARE COMPUTED AS THE RATIO OF THE TOTAL ENERGY USED TO THE TOTAL GROSS FLOOR AREA.

BTU/GSF-DEG.DAY IS A PARAMETER PROVIDING A COMMON BASIS OF COMPARISON OF BUILDING ENERGY USAGE REGARDLESS OF CLIMATE OR YEAR. 'AVERAGE' VALUES OF THIS PARAMETER ARE WEIGHTED AVERAGES, WEIGHTED BY THE % OF TOTAL ENERGY USE.

# ALPHABETIC LISTING

| NO. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | USAGE OF ENERGY BTU/GSF /YR | BTU/GSF /DD | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | BLDR RIVER | BOULDER | HOSPITAL | 433007 | 8270 | 153822 | 2375 | 0 | 146543 | 338430 | 40.92 | 8.509 |
| 2 | CAPITOL | HELENA | OFFICE | 574420 | 8111 | 59098 | 5804 | 0 | 72991 | 127069 | 15.67 | 4.238 |
| 3 | DF & BLND | GREAT FALLS | SCHOOL | 113629 | 7219 | 13995 | 769 | 0 | 15221 | 133950 | 18.56 | .884 |
| 4 | E. M. C. | BILLINGS | SCHOOL | 717877 | 7003 | 101500 | 7540 | 0 | 117076 | 163087 | 23.29 | 6.798 |
| 5 | EAST. CNTR | GLENDIVE | SCHOOL | 23786 | 7050 | 3523 | 109 | 0 | 3542 | 148931 | 21.12 | .206 |
| 6 | GALEN | GALEN | HOSPITAL | 283349 | 8400 | 84816 | 1728 | 0 | 82230 | 290209 | 34.55 | 4.775 |
| 7 | HM FR AGED | LEWISTOWN | APT CMPLX | 57462 | 7660 | 15032 | 288 | 0 | 14510 | 252521 | 32.97 | .843 |
| 8 | M. S. U. | BOZEMAN | SCHOOL | 2143084 | 7775 | 431182 | 15634 | 0 | 441409 | 205969 | 26.49 | 25.630 |
| 9 | MNT. VIEW | HELENA | SCHOOL | 76757 | 8111 | 11000 | 340 | 0 | 11060 | 144092 | 17.77 | .642 |
| 10 | MT TECH | BUTTE | SCHOOL | 294645 | 9480 | 47770 | 1613 | 0 | 48495 | 164588 | 17.36 | 2.816 |
| 11 | N. M. C. | HAVRE | SCHOOL | 526214 | 7789 | 70611 | 1926 | 0 | 70122 | 133257 | 17.11 | 4.072 |
| 12 | PINE HILLS | MILES CITY | SCHOOL | 165968 | 7235 | 38831 | 796 | 0 | 37665 | 226939 | 31.37 | 2.187 |
| 13 | SWAN RIVER | SWAN LAKE | MISC | 22038 | 8300 | 0 | 319 | 4760 | 5847 | 265317 | 31.97 | .340 |
| 14 | U. OF M. | MISSOULA | SCHOOL | 2004910 | 7318 | 316704 | 19697 | 0 | 352239 | 175688 | 24.01 | 20.452 |
| 15 | VET. HOME | COLUMBIA FA | APT CMPLX | 88658 | 7777 | 18710 | 469 | 0 | 18438 | 207973 | 26.74 | 1.071 |
| 16 | W. M. C. | DILLON | SCHOOL | 451184 | 7675 | 69939 | 2360 | 0 | 70997 | 157358 | 20.50 | 4.122 |
| 17 | WRM SPRNGS | WARM SPRING | HOSPITAL | 642159 | 8400 | 219428 | 4801 | 0 | 213867 | 333044 | 39.65 | 12.418 |

# ENERGY USAGE LISTING
## LISTED IN DECREASING ORDER OF % OF TOTAL BUILDING ENERGY CONSUMED

| NO. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | USAGE OF ENERGY BTU/GSF /YR | BTU/GSF /DD | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | M. S. U. | BOZEMAN | SCHOOL | 2143084 | 7775 | 431182 | 15634 | 0 | 441409 | 205969 | 26.49 | 25.630 |
| 2 | U. OF M. | MISSOULA | SCHOOL | 2004910 | 7318 | 316704 | 19697 | 0 | 352239 | 175688 | 24.01 | 20.452 |
| 3 | WRM SPRNGS | WARM SPRING | HOSPITAL | 642159 | 8400 | 219428 | 4801 | 0 | 213867 | 333044 | 39.65 | 12.418 |
| 4 | BLDR RIVER | BOULDER | HOSPITAL | 433007 | 8270 | 153822 | 2375 | 0 | 146543 | 338430 | 40.92 | 8.509 |
| 5 | E. M. C. | BILLINGS | SCHOOL | 717877 | 7003 | 101500 | 7540 | 0 | 117076 | 163087 | 23.29 | 6.798 |
| 6 | GALEN | GALEN | HOSPITAL | 283349 | 8400 | 84816 | 1728 | 0 | 82230 | 290209 | 34.55 | 4.775 |
| 7 | CAPITOL | HELENA | OFFICE | 574420 | 8111 | 59098 | 5804 | 0 | 72991 | 127069 | 15.67 | 4.238 |
| 8 | W. M. C. | DILLON | SCHOOL | 451184 | 7675 | 69939 | 2360 | 0 | 70997 | 157358 | 20.50 | 4.122 |
| 9 | N. M. C. | HAVRE | SCHOOL | 526214 | 7789 | 70611 | 1926 | 0 | 70122 | 133257 | 17.11 | 4.072 |
| 10 | MT TECH | BUTTE | SCHOOL | 294645 | 9480 | 47770 | 1613 | 0 | 48495 | 164588 | 17.36 | 2.816 |
| 11 | PINE HILLS | MILES CITY | SCHOOL | 165968 | 7235 | 38831 | 796 | 0 | 37665 | 226939 | 31.37 | 2.187 |
| 12 | VET. HOME | COLUMBIA FA | APT CMPLX | 88658 | 7777 | 18710 | 469 | 0 | 18438 | 207973 | 26.74 | 1.071 |
| 13 | DF & BLND | GREAT FALLS | SCHOOL | 113629 | 7219 | 13995 | 769 | 0 | 15221 | 133950 | 18.56 | .884 |
| 14 | HM FR AGED | LEWISTOWN | APT CMPLX | 57462 | 7660 | 15032 | 288 | 0 | 14510 | 252521 | 32.97 | .843 |
| 15 | MNT. VIEW | HELENA | SCHOOL | 76757 | 8111 | 11000 | 340 | 0 | 11060 | 144092 | 17.77 | .642 |
| 16 | SWAN RIVER | SWAN LAKE | MISC | 22038 | 8300 | 0 | 319 | 4760 | 5847 | 265317 | 31.97 | .340 |
| 17 | EAST. CNTR | GLENDIVE | SCHOOL | 23786 | 7050 | 3523 | 109 | 0 | 3542 | 148931 | 21.12 | .206 |

# ENERGY USAGE LISTING
## LISTED IN DECREASING ORDER OF ENERGY USE PER FLOOR AREA PER DEGREE DAY

| NO. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | USAGE OF ENERGY BTU/GSF /YR | BTU/GSF /DD | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | BLDR RIVER | BOULDER | HOSPITAL | 433007 | 8270 | 153822 | 2375 | 0 | 146543 | 338430 | 40.92 | 8.509 |
| 2 | WRM SPRNGS | WARM SPRING | HOSPITAL | 642159 | 8400 | 219428 | 4801 | 0 | 213867 | 333044 | 39.65 | 12.418 |
| 3 | GALEN | GALEN | HOSPITAL | 283349 | 8400 | 84816 | 1728 | 0 | 82230 | 290209 | 34.55 | 4.775 |
| 4 | HM FR AGED | LEWISTOWN | APT CMPLX | 57462 | 7660 | 15032 | 288 | 0 | 14510 | 252521 | 32.97 | .843 |
| 5 | SWAN RIVER | SWAN LAKE | MISC | 22038 | 8300 | 0 | 319 | 4760 | 5847 | 265317 | 31.97 | .340 |
| 6 | PINE HILLS | MILES CITY | SCHOOL | 165968 | 7235 | 38831 | 796 | 0 | 37665 | 226939 | 31.37 | 2.187 |
| 7 | VET. HOME | COLUMBIA FA | APT CMPLX | 88658 | 7777 | 18710 | 469 | 0 | 18438 | 207973 | 26.74 | 1.071 |
| 8 | M. S. U. | BOZEMAN | SCHOOL | 2143084 | 7775 | 431182 | 15634 | 0 | 441409 | 205969 | 26.49 | 25.630 |
| 9 | U. OF M. | MISSOULA | SCHOOL | 2004910 | 7318 | 316704 | 19697 | 0 | 352239 | 175688 | 24.01 | 20.452 |
| 10 | E. M. C. | BILLINGS | SCHOOL | 717877 | 7003 | 101500 | 7540 | 0 | 117076 | 163087 | 23.29 | 6.798 |
| 11 | EAST. CNTR | GLENDIVE | SCHOOL | 23786 | 7050 | 3523 | 109 | 0 | 3542 | 148931 | 21.12 | .206 |
| 12 | W. M. C. | DILLON | SCHOOL | 451184 | 7675 | 69939 | 2360 | 0 | 70997 | 157358 | 20.50 | 4.122 |
| 13 | DF & BLND | GREAT FALLS | SCHOOL | 113629 | 7219 | 13995 | 769 | 0 | 15221 | 133950 | 18.56 | .884 |
| 14 | MNT. VIEW | HELENA | SCHOOL | 76757 | 8111 | 11000 | 340 | 0 | 11060 | 144092 | 17.77 | .642 |
| 15 | MT TECH | BUTTE | SCHOOL | 294645 | 9480 | 47770 | 1613 | 0 | 48495 | 164588 | 17.36 | 2.816 |
| 16 | N. M. C. | HAVRE | SCHOOL | 526214 | 7789 | 70611 | 1926 | 0 | 70122 | 133257 | 17.11 | 4.072 |
| 17 | CAPITOL | HELENA | OFFICE | 574420 | 8111 | 59098 | 5804 | 0 | 72991 | 127069 | 15.67 | 4.238 |

ENERGY USAGE LISTING FOR SCHOOL BUILDINGS
LISTED IN DECREASING ORDER OF ENERGY USE PER FLOOR AREA PER DEGREE DAY

| NO. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | USAGE OF ENERGY BTU/GSF /YR | BTU/GSF /DD | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | PINE HILLS | MILES CITY | SCHOOL | 165968 | 7235 | 38831 | 796 | 0 | 37665 | 226939 | 31.37 | 2.187 |
| 2 | M. S. U. | BOZEMAN | SCHOOL | 2143084 | 7775 | 431182 | 15634 | 0 | 441409 | 205969 | 26.49 | 25.630 |
| 3 | U. OF M. | MISSOULA | SCHOOL | 2004910 | 7318 | 316704 | 19697 | 0 | 352239 | 175688 | 24.01 | 20.452 |
| 4 | E. M. C. | BILLINGS | SCHOOL | 717877 | 7003 | 101500 | 7540 | 0 | 117076 | 163087 | 23.29 | 6.798 |
| 5 | EAST. CNTR | GLENDIVE | SCHOOL | 23786 | 7050 | 3523 | 109 | 0 | 3542 | 148931 | 21.12 | .206 |
| 6 | W. M. C. | DILLON | SCHOOL | 451184 | 7675 | 69939 | 2360 | 0 | 70997 | 157358 | 20.50 | 4.122 |
| 7 | DF & BLND | GREAT FALLS | SCHOOL | 113629 | 7219 | 13995 | 769 | 0 | 15221 | 133950 | 18.56 | .884 |
| 8 | MNT. VIEW | HELENA | SCHOOL | 76757 | 8111 | 11000 | 340 | 0 | 11060 | 144092 | 17.77 | .642 |
| 9 | MT TECH | BUTTE | SCHOOL | 294645 | 9480 | 47770 | 1613 | 0 | 48495 | 164588 | 17.36 | 2.816 |
| 10 | N. M. C. | HAVRE | SCHOOL | 526214 | 7789 | 70611 | 1926 | 0 | 70122 | 133257 | 17.11 | 4.072 |
| | AVERAGE | | SCHOOL | 651805 | | | | | | 179168 | 24.07 | |

ENERGY USAGE LISTING FOR APT CMPLX BUILDINGS
LISTED IN DECREASING ORDER OF ENERGY USE PER FLOOR AREA PER DEGREE DAY

| NO. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | USAGE OF ENERGY BTU/GSF /YR | BTU/GSF /DD | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | HM FR AGED | LEWISTOWN | APT CMPLX | 57462 | 7660 | 15032 | 288 | 0 | 14510 | 252521 | 32.97 | .843 |
| 2 | VET. HOME | COLUMBIA FA | APT CMPLX | 88658 | 7777 | 18710 | 469 | 0 | 18438 | 207973 | 26.74 | 1.071 |
| | AVERAGE | | APT CMPLX | 73060 | | | | | | 225492 | 29.48 | |

ENERGY USAGE LISTING FOR HOSPITAL BUILDINGS
LISTED IN DECREASING ORDER OF ENERGY USE PER FLOOR AREA PER DEGREE DAY

| NO. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | USAGE OF ENERGY BTU/GSF /YR | BTU/GSF /DD | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | BLDR RIVER | BOULDER | HOSPITAL | 433007 | 8270 | 153822 | 2375 | 0 | 146543 | 338430 | 40.92 | 8.509 |
| 2 | WRM SPRNGS | WARM SPRING | HOSPITAL | 642159 | 8400 | 219428 | 4801 | 0 | 213867 | 333044 | 39.65 | 12.418 |
| 3 | GALEN | GALEN | HOSPITAL | 283349 | 8400 | 84816 | 1728 | 0 | 82230 | 290209 | 34.55 | 4.775 |
| | AVERAGE | | HOSPITAL | 452838 | | | | | | 325826 | 39.12 | |

ENERGY USAGE LISTING FOR OFFICE BUILDINGS
LISTED IN DECREASING ORDER OF ENERGY USE PER FLOOR AREA PER DEGREE DAY

| NO. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION | | | | USAGE OF ENERGY | | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | BTU/GSF /YR | BTU/GSF /DD | |
| 1 | CAPITOL | HELENA | OFFICE | 574420 | 8111 | 59098 | 5804 | 0 | 72991 | 127069 | 15.67 | 4.238 |
| | AVERAGE | | OFFICE | 574420 | | | | | | 127069 | 15.67 | |

ENERGY USAGE LISTING FOR MISC BUILDINGS
LISTED IN DECREASING ORDER OF ENERGY USE PER FLOOR AREA PER DEGREE DAY

| O. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | USAGE OF ENERGY BTU/GSF /YR | BTU/GSF /DD | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | SWAN RIVER | SWAN LAKE | MISC | 22038 | 8300 | 0 | 319 | 4760 | 5847 | 265317 | 31.97 | .340 |
| | AVERAGE | | MISC | 22038 | | | | | | 265317 | 31.97 | |

# E N E R G Y  A U D I T  S U M M A R Y  1973

GENERAL DATA:

| | |
|---|---|
| NUMBER OF INSTITUTIONS IN AUDIT | 17 |
| TOTAL GROSS FLOOR AREA (SQUARE FEET) | 8619147 |

BUILDING FUELS:

| | |
|---|---|
| NATURAL GAS CONSUMPTION (MCF) | 1655961 |
| OTHER FUEL CONSUMPTION (MMBTU) | 4760 |

ELECTRICITY:

| | |
|---|---|
| ELECTRICAL CONSUMPTION (MKWH) | 66567 |

TOTAL ENERGY:

| | |
|---|---|
| TOTAL ENERGY CONSUMPTION (MMBTU) | 1722252 |

ENERGY USAGE

| | | |
|---|---|---|
| BTU/GSF/YR | = | 199817 |
| BTU/GSF/DD | = | 27.71 |

# E N E R G Y  A U D I T  1974

FOR

ENERGY CONSERVATION STUDY

MONTANA

JANUARY 5, 1979

BY

DRAPES ENGINEERING
202 EKLUND BUILDING
GREAT FALLS, MONTANA

JOB NO. 77129

# DESCRIPTION OF OUTPUT LISTING

LOCATION: CITY NAME, (MONTANA ASSUMED AS THE STATE, UNLESS SPECIFIED OTHERWISE).

BUILDING TYPE: DESCRIBES MAJOR USE OF FACILITY.

BUILDING AREA: TOTAL AREA OF ALL FLOORS, IN GROSS SQUARE FEET (GSF).

HEATING DEGREE DAYS: ANNUAL TOTAL OF DIFFERENCE BETWEEN DAILY MEAN TEMP. AND 65 °F.

ENERGY CONSUMPTION: BASED ON UTILITY BILLING RECORDS.

GAS: AMOUNT USED DURING THE YEAR, IN THOUSANDS OF CUBIC FEET, (MCF).

ELECTRIC: AMOUNT USED DURING THE YEAR, INDICATED IN THOUSANDS OF KWH, (MKWH).

OTHER: ANY OTHER ENERGY SOURCE,LISTED BY ENERGY CONTENT IN MILLIONS OF BTU, (MMBTU).

TOTAL: AMOUNT OF ENERGY USED DURING AUDIT YEAR, IN MILLIONS OF BTU, (MMBTU).

USAGE OF ENERGY:

BTU/GSF-YR IS A PARAMETER PROVIDING A COMMON BASIS OF COMPARISON OF ENERGY USAGE FOR BUILDINGS HAVING SIMILAR CLIMATIC CONDITIONS. 'AVERAGE' VALUES OF THIS PARAMETER ARE COMPUTED AS THE RATIO OF THE TOTAL ENERGY USED TO THE TOTAL GROSS FLOOR AREA.

BTU/GSF-DEG.DAY IS A PARAMETER PROVIDING A COMMON BASIS OF COMPARISON OF BUILDING ENERGY USAGE REGARDLESS OF CLIMATE OR YEAR. 'AVERAGE' VALUES OF THIS PARAMETER ARE WEIGHTED AVERAGES, WEIGHTED BY THE OF TOTAL ENERGY USE.

ALPHABETIC LISTING

| NO. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | USAGE OF ENERGY BTU/GSF /YR | BTU/GSF /DD | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | BLDR RIVER | BOULDER | HOSPITAL | 427721 | 7820 | 134630 | 1716 | 0 | 127023 | 296977 | 37.98 | 7.499 |
| 2 | CAPITOL | HELENA | OFFICE | 574420 | 7560 | 65031 | 5451 | 0 | 77126 | 134268 | 17.76 | 4.553 |
| 3 | DF & BLND | GREAT FALLS | SCHOOL | 113629 | 6960 | 14606 | 792 | 0 | 15848 | 139471 | 20.04 | .936 |
| 4 | E. M. C. | BILLINGS | SCHOOL | 764919 | 6740 | 95500 | 8130 | 0 | 113690 | 148630 | 22.05 | 6.712 |
| 5 | EAST. CNTR | GLENDIVE | SCHOOL | 23786 | 6990 | 3389 | 98 | 0 | 3384 | 142277 | 20.35 | .200 |
| 6 | GALEN | GALEN | HOSPITAL | 283349 | 8140 | 81325 | 1470 | 0 | 78207 | 276010 | 33.91 | 4.617 |
| 7 | HM FR AGED | LEWISTOWN | APT CMPLX | 57462 | 7610 | 14394 | 269 | 0 | 13873 | 241426 | 31.72 | .819 |
| 8 | M. S. U. | BOZEMAN | SCHOOL | 2143084 | 7330 | 431971 | 15212 | 0 | 440677 | 205627 | 28.05 | 26.017 |
| 9 | MNT. VIEW | HELENA | SCHOOL | 76757 | 7560 | 11000 | 340 | 0 | 11060 | 144092 | 19.06 | .653 |
| 10 | MT TECH | BUTTE | SCHOOL | 294645 | 9160 | 47869 | 1600 | 0 | 48542 | 164748 | 17.99 | 2.866 |
| 11 | N. M. C. | HAVRE | SCHOOL | 526214 | 7530 | 74594 | 1496 | 0 | 72240 | 137282 | 18.23 | 4.265 |
| 12 | PINE HILLS | MILES CITY | SCHOOL | 165968 | 7090 | 34847 | 788 | 0 | 34050 | 205162 | 28.94 | 2.010 |
| 13 | SWAN RIVER | SWAN LAKE | MISC | 22038 | 8060 | 0 | 377 | 4760 | 6045 | 274282 | 34.03 | .357 |
| 14 | U. OF M. | MISSOULA | SCHOOL | 2221468 | 7220 | 322235 | 18660 | 0 | 353679 | 159210 | 22.05 | 20.881 |
| 15 | VET. HOME | COLUMBIA FA | APT CMPLX | 88658 | 7630 | 21435 | 565 | 0 | 21218 | 239320 | 31.37 | 1.253 |
| 16 | W. M. C. | DILLON | SCHOOL | 451184 | 7260 | 64642 | 2153 | 0 | 65523 | 145225 | 20.00 | 3.868 |
| 17 | WRM SPRNGS | WARM SPRING | HOSPITAL | 642159 | 8140 | 216420 | 4938 | 0 | 211628 | 329557 | 40.49 | 12.494 |

# ENERGY USAGE LISTING
## LISTED IN DECREASING ORDER OF % OF TOTAL BUILDING ENERGY CONSUMED

| NO. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | USAGE OF ENERGY BTU/GSF /YR | BTU/GSF /DD | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | M. S. U. | BOZEMAN | SCHOOL | 2143084 | 7330 | 431971 | 15212 | 0 | 440677 | 205627 | 28.05 | 26.017 |
| 2 | U. OF M. | MISSOULA | SCHOOL | 2221468 | 7220 | 322235 | 10660 | 0 | 353679 | 159210 | 22.05 | 20.881 |
| 3 | WRM SPRNGS | WARM SPRING | HOSPITAL | 642159 | 8140 | 216420 | 4938 | 0 | 211628 | 329557 | 40.49 | 12.494 |
| 4 | BLDR RIVER | BOULDER | HOSPITAL | 427721 | 7820 | 134630 | 1716 | 0 | 127023 | 296977 | 37.98 | 7.499 |
| 5 | E. M. C. | BILLINGS | SCHOOL | 764919 | 6740 | 95500 | 8130 | 0 | 113690 | 148630 | 22.05 | 6.712 |
| 6 | GALEN | GALEN | HOSPITAL | 283349 | 8140 | 81325 | 1470 | 0 | 78207 | 276010 | 33.91 | 4.617 |
| 7 | CAPITOL | HELENA | OFFICE | 574420 | 7560 | 65031 | 5451 | 0 | 77126 | 134268 | 17.76 | 4.553 |
| 8 | N. M. C. | HAVRE | SCHOOL | 526214 | 7530 | 74594 | 1496 | 0 | 72240 | 137282 | 18.23 | 4.265 |
| 9 | W. M. C. | DILLON | SCHOOL | 451184 | 7260 | 64642 | 2153 | 0 | 65523 | 145225 | 20.00 | 3.868 |
| 10 | MT TECH | BUTTE | SCHOOL | 294645 | 9160 | 47869 | 1600 | 0 | 48542 | 164748 | 17.99 | 2.866 |
| 11 | PINE HILLS | MILES CITY | SCHOOL | 165968 | 7090 | 34847 | 788 | 0 | 34050 | 205162 | 28.94 | 2.010 |
| 12 | VET. HOME | COLUMBIA FA | APT CMPLX | 88658 | 7630 | 21435 | 565 | 0 | 21218 | 239320 | 31.37 | 1.253 |
| 13 | DF & BLND | GREAT FALLS | SCHOOL | 113629 | 6960 | 14606 | 792 | 0 | 15848 | 139471 | 20.04 | .936 |
| 14 | HM FR AGED | LEWISTOWN | APT CMPLX | 57462 | 7610 | 14394 | 269 | 0 | 13873 | 241426 | 31.72 | .819 |
| 15 | MNT. VIEW | HELENA | SCHOOL | 76757 | 7560 | 11000 | 340 | 0 | 11060 | 144092 | 19.06 | .653 |
| 16 | SWAN RIVER | SWAN LAKE | MISC | 22038 | 8060 | 0 | 377 | 4760 | 6045 | 274282 | 34.03 | .357 |
| 17 | EAST. CNTR | GLENDIVE | SCHOOL | 23786 | 6990 | 3389 | 98 | 0 | 3384 | 142277 | 20.35 | .200 |

# ENERGY USAGE LISTING
## LISTED IN DECREASING ORDER OF ENERGY USE PER FLOOR AREA PER DEGREE DAY

| NO. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | USAGE OF ENERGY BTU/GSF /YR | BTU/GSF /DD | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | WRM SPRNGS | WARM SPRING | HOSPITAL | 642159 | 8140 | 216420 | 4938 | 0 | 211628 | 329557 | 40.49 | 12.494 |
| 2 | BLDR RIVER | BOULDER | HOSPITAL | 427721 | 7820 | 134630 | 1716 | 0 | 127023 | 296977 | 37.98 | 7.499 |
| 3 | SWAN RIVER | SWAN LAKE | MISC | 22038 | 8060 | 0 | 377 | 4760 | 6045 | 274282 | 34.03 | .357 |
| 4 | GALEN | GALEN | HOSPITAL | 283349 | 8140 | 81325 | 1470 | 0 | 78207 | 276010 | 33.91 | 4.617 |
| 5 | HM FR AGED | LEWISTOWN | APT CMPLX | 57462 | 7610 | 14394 | 269 | 0 | 13873 | 241426 | 31.72 | .819 |
| 6 | VET. HOME | COLUMBIA FA | APT CMPLX | 88658 | 7630 | 21435 | 565 | 0 | 21218 | 239320 | 31.37 | 1.253 |
| 7 | PINE HILLS | MILES CITY | SCHOOL | 165968 | 7090 | 34847 | 788 | 0 | 34050 | 205162 | 28.94 | 2.010 |
| 8 | M. S. U. | BOZEMAN | SCHOOL | 2143084 | 7330 | 431971 | 15212 | 0 | 440677 | 205627 | 28.05 | 26.017 |
| 9 | E. M. C. | BILLINGS | SCHOOL | 764919 | 6740 | 95500 | 8130 | 0 | 113690 | 148630 | 22.05 | 6.712 |
| 10 | U. OF M. | MISSOULA | SCHOOL | 2221468 | 7220 | 322235 | 18660 | 0 | 353679 | 159210 | 22.05 | 20.881 |
| 11 | EAST. CNTR | GLENDIVE | SCHOOL | 23786 | 6990 | 3389 | 98 | 0 | 3384 | 142277 | 20.35 | .200 |
| 12 | DF & BLND | GREAT FALLS | SCHOOL | 113629 | 6960 | 14606 | 792 | 0 | 15848 | 139471 | 20.04 | .936 |
| 13 | W. M. C. | DILLON | SCHOOL | 451184 | 7260 | 64642 | 2153 | 0 | 65523 | 145225 | 20.00 | 3.868 |
| 14 | MNT. VIEW | HELENA | SCHOOL | 76757 | 7560 | 11000 | 340 | 0 | 11060 | 144092 | 19.06 | .653 |
| 15 | N. M. C. | HAVRE | SCHOOL | 526214 | 7530 | 74594 | 1496 | 0 | 72240 | 137282 | 18.23 | 4.265 |
| 16 | MT TECH | BUTTE | SCHOOL | 294645 | 9160 | 47869 | 1600 | 0 | 48542 | 164748 | 17.99 | 2.866 |
| 17 | CAPITOL | HELENA | OFFICE | 574420 | 7560 | 65031 | 5451 | 0 | 77126 | 134268 | 17.76 | 4.553 |

ENERGY USAGE LISTING FOR SCHOOL BUILDINGS
LISTED IN DECREASING ORDER OF ENERGY USE PER FLOOR AREA PER DEGREE DAY

| O. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | USAGE OF ENERGY BTU/GSF /YR | BTU/GSF /DD | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | PINE HILLS | MILES CITY | SCHOOL | 165968 | 7090 | 34847 | 788 | 0 | 34050 | 205162 | 28.94 | 2.010 |
| 2 | M. S. U. | BOZEMAN | SCHOOL | 2143084 | 7330 | 431971 | 15212 | 0 | 440677 | 205627 | 28.05 | 26.017 |
| 3 | E. M. C. | BILLINGS | SCHOOL | 764919 | 6740 | 95500 | 8130 | 0 | 113690 | 148630 | 22.05 | 6.712 |
| 4 | U. OF M. | MISSOULA | SCHOOL | 2221468 | 7220 | 322235 | 18660 | 0 | 353679 | 159210 | 22.05 | 20.881 |
| 5 | EAST. CNTR | GLENDIVE | SCHOOL | 23786 | 6990 | 3389 | 98 | 0 | 3384 | 142277 | 20.35 | .200 |
| 6 | DF & BLND | GREAT FALLS | SCHOOL | 113629 | 6960 | 14606 | 792 | 0 | 15848 | 139471 | 20.04 | .936 |
| 7 | W. M. C. | DILLON | SCHOOL | 451184 | 7260 | 64642 | 2153 | 0 | 65523 | 145225 | 20.00 | 3.868 |
| 8 | MNT. VIEW | HELENA | SCHOOL | 76757 | 7560 | 11000 | 340 | 0 | 11060 | 144092 | 19.06 | .653 |
| 9 | N. M. C. | HAVRE | SCHOOL | 526214 | 7530 | 74594 | 1496 | 0 | 72240 | 137282 | 18.23 | 4.265 |
| 10 | MT TECH | BUTTE | SCHOOL | 294645 | 9160 | 47869 | 1600 | 0 | 48542 | 164748 | 17.99 | 2.866 |
| | AVERAGE | | SCHOOL | 678165 | | | | | | 170857 | 23.95 | |

ENERGY USAGE LISTING FOR APT CMPLX BUILDINGS
LISTED IN DECREASING ORDER OF ENERGY USE PER FLOOR AREA PER DEGREE DAY

| O. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | USAGE OF ENERGY BTU/GSF /YR | BTU/GSF /DD | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | HM FR AGED | LEWISTOWN | APT CMPLX | 57462 | 7610 | 14394 | 269 | 0 | 13873 | 241426 | 31.72 | .819 |
| 2 | VET. HOME | COLUMBIA FA | APT CMPLX | 88658 | 7630 | 21435 | 565 | 0 | 21218 | 239320 | 31.37 | 1.253 |
| | AVERAGE | | APT CMPLX | 73060 | | | | | | 240149 | 31.51 | |

ENERGY USAGE LISTING FOR HOSPITAL BUILDINGS
LISTED IN DECREASING ORDER OF ENERGY USE PER FLOOR AREA PER DEGREE DAY

| O. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | USAGE OF ENERGY BTU/GSF /YR | BTU/GSF /DD | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | WRM SPRNGS | WARM SPRING | HOSPITAL | 642159 | 8140 | 216420 | 4938 | 0 | 211628 | 329557 | 40.49 | 12.494 |
| 2 | BLDR RIVER | BOULDER | HOSPITAL | 427721 | 7820 | 134630 | 1716 | 0 | 127023 | 296977 | 37.98 | 7.499 |
| 3 | GALEN | GALEN | HOSPITAL | 283349 | 8140 | 81325 | 1470 | 0 | 78207 | 276010 | 33.91 | 4.617 |
| | AVERAGE | | HOSPITAL | 451076 | | | | | | 308047 | 38.49 | |

ENERGY USAGE LISTING FOR OFFICE BUILDINGS
LISTED IN DECREASING ORDER OF ENERGY USE PER FLOOR AREA PER DEGREE DAY

| O. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | USAGE OF ENERGY BTU/GSF /YR | BTU/GSF /DD | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | CAPITOL | HELENA | OFFICE | 574420 | 7560 | 65031 | 5451 | 0 | 77126 | 134268 | 17.76 | 4.553 |
| | AVERAGE | | OFFICE | 574420 | | | | | | 134268 | 17.76 | |

ENERGY USAGE LISTING FOR MISC BUILDINGS
LISTED IN DECREASING ORDER OF ENERGY USE PER FLOOR AREA PER DEGREE DAY

| O. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | USAGE OF ENERGY BTU/GSF /YR | BTU/GSF /DD | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | SWAN RIVER | SWAN LAKE | MISC | 22038 | 8060 | 0 | 377 | 4768 | 6045 | 274282 | 34.03 | .357 |
| | AVERAGE | | MISC | 22038 | | | | | | 274282 | 34.03 | |

# E N E R G Y  A U D I T  S U M M A R Y  1974

GENERAL DATA:

| | |
|---|---|
| NUMBER OF INSTITUTIONS IN AUDIT | 17 |
| TOTAL GROSS FLOOR AREA (SQUARE FEET) | 8877461 |

BUILDING FUELS:

| | |
|---|---|
| NATURAL GAS CONSUMPTION (MCF) | 1633888 |
| OTHER FUEL CONSUMPTION (MMBTU) | 4760 |

ELECTRICITY:

| | |
|---|---|
| ELECTRICAL CONSUMPTION (MKWH) | 64054 |

TOTAL ENERGY:

| | |
|---|---|
| TOTAL ENERGY CONSUMPTION (MMBTU) | 1693812 |

ENERGY USAGE

| | | |
|---|---|---|
| BTU/GSF/YR | = | 190799 |
| BTU/GSF/DD | = | 27.44 |

# E N E R G Y  A U D I T  1975

FOR

ENERGY CONSERVATION STUDY

MONTANA

JANUARY 5, 1979

BY

DRAPES ENGINEERING
202 EKLUND BUILDING
GREAT FALLS, MONTANA

JOB NO. 77129

# DESCRIPTION OF OUTPUT LISTING

LOCATION: CITY NAME, (MONTANA ASSUMED AS THE STATE, UNLESS SPECIFIED OTHERWISE).

BUILDING TYPE: DESCRIBES MAJOR USE OF FACILITY.

BUILDING AREA: TOTAL AREA OF ALL FLOORS, IN GROSS SQUARE FEET (GSF).

HEATING DEGREE DAYS: ANNUAL TOTAL OF DIFFERENCE BETWEEN DAILY MEAN TEMP. AND 65 °F.

ENERGY CONSUMPTION: BASED ON UTILITY BILLING RECORDS.

GAS: AMOUNT USED DURING THE YEAR, IN THOUSANDS OF CUBIC FEET, (MCF).

ELECTRIC: AMOUNT USED DURING THE YEAR, INDICATED IN THOUSANDS OF KWH, (MKWH).

OTHER: ANY OTHER ENERGY SOURCE,LISTED BY ENERGY CONTENT IN MILLIONS OF BTU, (MMBTU).

TOTAL: AMOUNT OF ENERGY USED DURING AUDIT YEAR, IN MILLIONS OF BTU, (MMBTU).

USAGE OF ENERGY:

BTU/GSF-YR IS A PARAMETER PROVIDING A COMMON BASIS OF COMPARISON OF ENERGY USAGE FOR BUILDINGS HAVING SIMILAR CLIMATIC CONDITIONS. 'AVERAGE' VALUES OF THIS PARAMETER ARE COMPUTED AS THE RATIO OF THE TOTAL ENERGY USED TO THE TOTAL GROSS FLOOR AREA.

BTU/GSF-DEG.DAY IS A PARAMETER PROVIDING A COMMON BASIS OF COMPARISON OF BUILDING ENERGY USAGE REGARDLESS OF CLIMATE OR YEAR. 'AVERAGE' VALUES OF THIS PARAMETER ARE WEIGHTED AVERAGES, WEIGHTED BY THE OF TOTAL ENERGY USE.

ALPHABETIC LISTING

| ID. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | USAGE OF ENERGY BTU/GSF /YR | BTU/GSF /DD | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | BLDR RIVER | BOULDER | HOSPITAL | 411863 | 9024 | 154163 | 1367 | 0 | 143410 | 348199 | 38.59 | 8.155 |
| 2 | CAPITOL | HELENA | OFFICE | 574420 | 8953 | 66594 | 5576 | 0 | 78960 | 137460 | 15.35 | 4.490 |
| 3 | DF & BLND | GREAT FALLS | SCHOOL | 113629 | 8560 | 15336 | 794 | 0 | 16512 | 145311 | 16.98 | .939 |
| 4 | E. M. C. | BILLINGS | SCHOOL | 754323 | 7861 | 97300 | 6910 | 0 | 111147 | 147347 | 18.74 | 6.320 |
| 5 | EAST. CNTR | GLENDIVE | SCHOOL | 23786 | 7838 | 3765 | 99 | 0 | 3727 | 156676 | 19.99 | .212 |
| 6 | GALEN | GALEN | HOSPITAL | 283349 | 9138 | 89749 | 1607 | 0 | 86257 | 304418 | 33.31 | 4.905 |
| 7 | HM FR AGED | LEWISTOWN | APT CMPLX | 57462 | 9281 | 14396 | 256 | 0 | 13829 | 240664 | 25.93 | .786 |
| 8 | M. S. U. | BOZEMAN | SCHOOL | 2474742 | 8486 | 453015 | 16611 | 0 | 464389 | 187652 | 22.11 | 26.407 |
| 9 | MNT. VIEW | HELENA | SCHOOL | 76757 | 8953 | 11087 | 341 | 0 | 11143 | 145173 | 16.21 | .634 |
| 10 | MT TECH | BUTTE | SCHOOL | 343575 | 11208 | 51714 | 1843 | 0 | 52832 | 153771 | 13.72 | 3.004 |
| 11 | N. M. C. | HAVRE | SCHOOL | 526214 | 8735 | 83343 | 1463 | 0 | 80002 | 152033 | 17.41 | 4.549 |
| 12 | PINE HILLS | MILES CITY | SCHOOL | 165968 | 8122 | 37683 | 905 | 0 | 37002 | 222945 | 27.45 | 2.104 |
| 13 | SWAN RIVER | SWAN LAKE | MISC | 22038 | 8627 | 0 | 425 | 4760 | 6211 | 281852 | 32.67 | .353 |
| 14 | U. OF M. | MISSOULA | SCHOOL | 2252748 | 8290 | 317953 | 18935 | 0 | 350763 | 155705 | 18.78 | 19.946 |
| 15 | VET. HOME | COLUMBIA FA | APT CMPLX | 88658 | 8664 | 20613 | 614 | 0 | 20647 | 232884 | 26.88 | 1.174 |
| 16 | W. M. C. | DILLON | SCHOOL | 451184 | 8929 | 74199 | 2108 | 0 | 73972 | 163950 | 18.36 | 4.206 |
| 17 | WRM SPRNGS | WARM SPRING | HOSPITAL | 642159 | 9138 | 213233 | 4651 | 0 | 207780 | 323564 | 35.41 | 11.815 |

# ENERGY USAGE LISTING
## LISTED IN DECREASING ORDER OF % OF TOTAL BUILDING ENERGY CONSUMED

| O. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION | | | | USAGE OF ENERGY | | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | BTU/GSF /YR | BTU/GSF /DD | |
| 1 | M. S. U. | BOZEMAN | SCHOOL | 2474742 | 8486 | 453015 | 16611 | 0 | 464389 | 187652 | 22.11 | 26.407 |
| 2 | U. OF M. | MISSOULA | SCHOOL | 2252748 | 8290 | 317953 | 18935 | 0 | 350763 | 155705 | 18.78 | 19.946 |
| 3 | WRM SPRNGS | WARM SPRING | HOSPITAL | 642159 | 9138 | 213233 | 4651 | 0 | 207780 | 323564 | 35.41 | 11.815 |
| 4 | BLDR RIVER | BOULDER | HOSPITAL | 411863 | 9024 | 154163 | 1367 | 0 | 143410 | 348199 | 38.59 | 8.155 |
| 5 | E. M. C. | BILLINGS | SCHOOL | 754323 | 7861 | 97300 | 6910 | 0 | 111147 | 147347 | 18.74 | 6.320 |
| 6 | GALEN | GALEN | HOSPITAL | 283349 | 9138 | 89749 | 1607 | 0 | 86257 | 304418 | 33.31 | 4.905 |
| 7 | N. M. C. | HAVRE | SCHOOL | 526214 | 8735 | 83343 | 1463 | 0 | 80002 | 152033 | 17.41 | 4.549 |
| 8 | CAPITOL | HELENA | OFFICE | 574420 | 8953 | 66594 | 5576 | 0 | 78960 | 137460 | 15.35 | 4.490 |
| 9 | W. M. C. | DILLON | SCHOOL | 451184 | 8929 | 74199 | 2108 | 0 | 73972 | 163950 | 18.36 | 4.206 |
| 10 | MT TECH | BUTTE | SCHOOL | 343575 | 11208 | 51714 | 1843 | 0 | 52832 | 153771 | 13.72 | 3.004 |
| 11 | PINE HILLS | MILES CITY | SCHOOL | 165968 | 8122 | 37683 | 905 | 0 | 37002 | 222945 | 27.45 | 2.104 |
| 12 | VET. HOME | COLUMBIA FA | APT CMPLX | 88658 | 8664 | 20613 | 614 | 0 | 20647 | 232884 | 26.88 | 1.174 |
| 13 | DF & BLND | GREAT FALLS | SCHOOL | 113629 | 8560 | 15336 | 794 | 0 | 16512 | 145311 | 16.98 | .939 |
| 14 | HM FR AGED | LEWISTOWN | APT CMPLX | 57462 | 9281 | 14396 | 256 | 0 | 13829 | 240664 | 25.93 | .786 |
| 15 | MNT. VIEW | HELENA | SCHOOL | 76757 | 8953 | 11087 | 341 | 0 | 11143 | 145173 | 16.21 | .634 |
| 16 | SWAN RIVER | SWAN LAKE | MISC | 22038 | 8627 | 0 | 425 | 4760 | 6211 | 281852 | 32.67 | .353 |
| 17 | EAST. CNTR | GLENDIVE | SCHOOL | 23786 | 7838 | 3765 | 99 | 0 | 3727 | 156676 | 19.99 | .212 |

# ENERGY USAGE LISTING
## LISTED IN DECREASING ORDER OF ENERGY USE PER FLOOR AREA PER DEGREE DAY

| NO. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | USAGE OF ENERGY BTU/GSF /YR | BTU/GSF /DD | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | BLDR RIVER | BOULDER | HOSPITAL | 411863 | 9024 | 154163 | 1367 | 0 | 143410 | 348199 | 38.59 | 8.155 |
| 2 | WRM SPRNGS | WARM SPRING | HOSPITAL | 642159 | 9138 | 213233 | 4651 | 0 | 207780 | 323564 | 35.41 | 11.815 |
| 3 | GALEN | GALEN | HOSPITAL | 283349 | 9138 | 89749 | 1607 | 0 | 86257 | 304418 | 33.31 | 4.905 |
| 4 | SWAN RIVER | SWAN LAKE | MISC | 22038 | 8627 | 0 | 425 | 4760 | 6211 | 281852 | 32.67 | .353 |
| 5 | PINE HILLS | MILES CITY | SCHOOL | 165968 | 8122 | 37683 | 905 | 0 | 37002 | 222945 | 27.45 | 2.104 |
| 6 | VET. HOME | COLUMBIA FA | APT CMPLX | 88658 | 8664 | 20613 | 614 | 0 | 20647 | 232884 | 26.88 | 1.174 |
| 7 | HM FR AGED | LEWISTOWN | APT CMPLX | 57462 | 9281 | 14396 | 256 | 0 | 13829 | 240664 | 25.93 | .786 |
| 8 | M. S. U. | BOZEMAN | SCHOOL | 2474742 | 8486 | 453015 | 16611 | 0 | 464389 | 187652 | 22.11 | 26.407 |
| 9 | EAST. CNTR | GLENDIVE | SCHOOL | 23786 | 7838 | 3765 | 99 | 0 | 3727 | 156676 | 19.99 | .212 |
| 10 | U. OF M. | MISSOULA | SCHOOL | 2252748 | 8290 | 317953 | 18935 | 0 | 350763 | 155705 | 18.78 | 19.946 |
| 11 | E. M. C. | BILLINGS | SCHOOL | 754323 | 7861 | 97300 | 6910 | 0 | 111147 | 147347 | 18.74 | 6.320 |
| 12 | W. M. C. | DILLON | SCHOOL | 451184 | 8929 | 74199 | 2108 | 0 | 73972 | 163950 | 18.36 | 4.206 |
| 13 | N. M. C. | HAVRE | SCHOOL | 526214 | 8735 | 83343 | 1463 | 0 | 80002 | 152033 | 17.41 | 4.549 |
| 14 | DF & BLND | GREAT FALLS | SCHOOL | 113629 | 8560 | 15336 | 794 | 0 | 16512 | 145311 | 16.98 | .939 |
| 15 | MNT. VIEW | HELENA | SCHOOL | 76757 | 8953 | 11087 | 341 | 0 | 11143 | 145173 | 16.21 | .634 |
| 16 | CAPITOL | HELENA | OFFICE | 574420 | 8953 | 66594 | 5576 | 0 | 78960 | 137460 | 15.35 | 4.490 |
| 17 | MT TECH | BUTTE | SCHOOL | 343575 | 11208 | 51714 | 1843 | 0 | 52832 | 153771 | 13.72 | 3.004 |

ENERGY USAGE LISTING FOR SCHOOL BUILDINGS
LISTED IN DECREASING ORDER OF ENERGY USE PER FLOOR AREA PER DEGREE DAY

| O. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | USAGE OF ENERGY BTU/GSF /YR | BTU/GSF /DD | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | PINE HILLS | MILES CITY | SCHOOL | 165968 | 8122 | 37683 | 905 | 0 | 37002 | 222945 | 27.45 | 2.104 |
| 2 | M. S. U. | BOZEMAN | SCHOOL | 2474742 | 8486 | 453015 | 16611 | 0 | 464389 | 187652 | 22.11 | 26.407 |
| 3 | EAST. CNTR | GLENDIVE | SCHOOL | 23786 | 7838 | 3765 | 99 | 0 | 3727 | 156676 | 19.99 | .212 |
| 4 | U. OF M. | MISSOULA | SCHOOL | 2252748 | 8290 | 317953 | 18935 | 0 | 350763 | 155705 | 18.78 | 19.946 |
| 5 | E. M. C. | BILLINGS | SCHOOL | 754323 | 7861 | 97300 | 6910 | 0 | 111147 | 147347 | 18.74 | 6.320 |
| 6 | W. M. C. | DILLON | SCHOOL | 451184 | 8929 | 74199 | 2108 | 0 | 73972 | 163950 | 18.36 | 4.206 |
| 7 | N. M. C. | HAVRE | SCHOOL | 526214 | 8735 | 83343 | 1463 | 0 | 80002 | 152033 | 17.41 | 4.549 |
| 8 | DF & BLND | GREAT FALLS | SCHOOL | 113629 | 8560 | 15336 | 794 | 0 | 16512 | 145311 | 16.98 | .939 |
| 9 | MNT. VIEW | HELENA | SCHOOL | 76757 | 8953 | 11087 | 341 | 0 | 11143 | 145173 | 16.21 | .634 |
| 10 | MT TECH | BUTTE | SCHOOL | 343575 | 11208 | 51714 | 1843 | 0 | 52832 | 153771 | 13.72 | 3.004 |
| | AVERAGE | | SCHOOL | 718293 | | | | | | 167270 | 19.95 | |

ENERGY USAGE LISTING FOR APT CMPLX BUILDINGS
LISTED IN DECREASING ORDER OF ENERGY USE PER FLOOR AREA PER DEGREE DAY

| NO. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | USAGE OF ENERGY BTU/GSF /YR | BTU/GSF /DD | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | VET. HOME | COLUMBIA FA | APT CMPLX | 88658 | 8664 | 20613 | 614 | 0 | 20647 | 232884 | 26.88 | 1.174 |
| 2 | HM FR AGED | LEWISTOWN | APT CMPLX | 57462 | 9281 | 14396 | 256 | 0 | 13829 | 240664 | 25.93 | .786 |
| | AVERAGE | | APT CMPLX | 73060 | | | | | | 235943 | 26.50 | |

ENERGY USAGE LISTING FOR HOSPITAL BUILDINGS
LISTED IN DECREASING ORDER OF ENERGY USE PER FLOOR AREA PER DEGREE DAY

| NO. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | USAGE OF ENERGY BTU/GSF /YR | BTU/GSF /DD | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | BLDR RIVER | BOULDER | HOSPITAL | 411863 | 9024 | 154163 | 1367 | 0 | 143410 | 348199 | 38.59 | 8.155 |
| 2 | WRM SPRNGS | WARM SPRING | HOSPITAL | 642159 | 9138 | 213233 | 4651 | 0 | 207780 | 323564 | 35.41 | 11.815 |
| 3 | GALEN | GALEN | HOSPITAL | 283349 | 9138 | 89749 | 1607 | 0 | 86257 | 304418 | 33.31 | 4.905 |
| | AVERAGE | | HOSPITAL | 445790 | | | | | | 327094 | 36.04 | |

ENERGY USAGE LISTING FOR OFFICE BUILDINGS
LISTED IN DECREASING ORDER OF ENERGY USE PER FLOOR AREA PER DEGREE DAY

| ID. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | USAGE OF ENERGY BTU/GSF /YR | BTU/GSF /DD | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | CAPITOL | HELENA | OFFICE | 574420 | 8953 | 66594 | 5576 | 0 | 78960 | 137460 | 15.35 | 4.490 |
| | AVERAGE | | OFFICE | 574420 | | | | | | 137460 | 15.35 | |

ENERGY USAGE LISTING FOR MISC BUILDINGS
LISTED IN DECREASING ORDER OF ENERGY USE PER FLOOR AREA PER DEGREE DAY

| NO. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION | | | | USAGE OF ENERGY | | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | BTU/GSF /YR | BTU/GSF /DD | |
| 1 | SWAN RIVER | SWAN LAKE | MISC | 22038 | 8627 | 0 | 425 | 4760 | 6211 | 281852 | 32.67 | .353 |
| | AVERAGE | | MISC | 22038 | | | | | | 281852 | 32.67 | |

# E N E R G Y  A U D I T  S U M M A R Y  1975

GENERAL DATA:

| | |
|---|---|
| NUMBER OF INSTITUTIONS IN AUDIT | 17 |
| TOTAL GROSS FLOOR AREA (SQUARE FEET) | 9262875 |

BUILDING FUELS:

| | |
|---|---|
| NATURAL GAS CONSUMPTION (MCF) | 1704143 |
| OTHER FUEL CONSUMPTION (MMBTU) | 4760 |

ELECTRICITY:

| | |
|---|---|
| ELECTRICAL CONSUMPTION (MKWH) | 64505 |

TOTAL ENERGY:

| | |
|---|---|
| TOTAL ENERGY CONSUMPTION (MMBTU) | 1758581 |

ENERGY USAGE

| | | |
|---|---|---|
| BTU/GSF/YR | = | 189852 |
| BTU/GSF/DD | = | 23.92 |

# E N E R G Y  A U D I T  1976

FOR

ENERGY CONSERVATION STUDY

MONTANA

JANUARY 5, 1979

BY

DRAPES ENGINEERING
202 EKLUND BUILDING
GREAT FALLS, MONTANA

JOB NO. 77129

# DESCRIPTION OF OUTPUT LISTING

LOCATION: CITY NAME, (MONTANA ASSUMED AS THE STATE, UNLESS SPECIFIED OTHERWISE).

BUILDING TYPE: DESCRIBES MAJOR USE OF FACILITY.

BUILDING AREA: TOTAL AREA OF ALL FLOORS, IN GROSS SQUARE FEET (GSF).

HEATING DEGREE DAYS: ANNUAL TOTAL OF DIFFERENCE BETWEEN DAILY MEAN TEMP. AND 65 °F.

ENERGY CONSUMPTION: BASED ON UTILITY BILLING RECORDS.

GAS: AMOUNT USED DURING THE YEAR, IN THOUSANDS OF CUBIC FEET, (MCF).

ELECTRIC: AMOUNT USED DURING THE YEAR, INDICATED IN THOUSANDS OF KWH, (MKWH).

OTHER: ANY OTHER ENERGY SOURCE,LISTED BY ENERGY CONTENT IN MILLIONS OF BTU, (MMBTU).

TOTAL: AMOUNT OF ENERGY USED DURING AUDIT YEAR, IN MILLIONS OF BTU, (MMBTU).

USAGE OF ENERGY:

BTU/GSF-YR IS A PARAMETER PROVIDING A COMMON BASIS OF COMPARISON OF ENERGY USAGE FOR BUILDINGS HAVING SIMILAR CLIMATIC CONDITIONS. 'AVERAGE' VALUES OF THIS PARAMETER ARE COMPUTED AS THE RATIO OF THE TOTAL ENERGY USED TO THE TOTAL GROSS FLOOR AREA.

BTU/GSF-DEG.DAY IS A PARAMETER PROVIDING A COMMON BASIS OF COMPARISON OF BUILDING ENERGY USAGE REGARDLESS OF CLIMATE OR YEAR. 'AVERAGE' VALUES OF THIS PARAMETER ARE WEIGHTED AVERAGES, WEIGHTED BY THE OF TOTAL ENERGY USE.

ALPHABETIC LISTING

| O. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | USAGE OF ENERGY BTU/GSF /YR | BTU/GSF /DD | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | BLDR RIVER | BOULDER | HOSPITAL | 381346 | 7683 | 129166 | 1360 | 0 | 120891 | 317012 | 41.26 | 7.521 |
| 2 | CAPITOL | HELENA | OFFICE | 574420 | 7502 | 57904 | 5841 | 0 | 72042 | 125417 | 16.72 | 4.482 |
| 3 | DF & BLND | GREAT FALLS | SCHOOL | 113629 | 6811 | 12768 | 852 | 0 | 14399 | 126723 | 18.61 | .896 |
| 4 | E. M. C. | BILLINGS | SCHOOL | 754323 | 6723 | 92100 | 7200 | 0 | 107456 | 142454 | 21.19 | 6.686 |
| 5 | EAST. CNTR | GLENDIVE | SCHOOL | 23786 | 7045 | 3248 | 138 | 0 | 3392 | 142622 | 20.24 | .211 |
| 6 | GALEN | GALEN | HOSPITAL | 283349 | 8013 | 82151 | 1627 | 0 | 79488 | 280530 | 35.01 | 4.945 |
| 7 | HM FR AGED | LEWISTOWN | APT CMPLX | 74764 | 7844 | 15403 | 376 | 0 | 15145 | 202572 | 25.83 | .942 |
| 8 | M. S. U. | BOZEMAN | SCHOOL | 2549635 | 7278 | 441505 | 16178 | 0 | 452553 | 177497 | 24.39 | 28.156 |
| 9 | MNT. VIEW | HELENA | SCHOOL | 76757 | 7502 | 10277 | 341 | 0 | 10411 | 135641 | 18.08 | .648 |
| 10 | MT TECH | BUTTE | SCHOOL | 343575 | 8980 | 46961 | 1967 | 0 | 48977 | 142553 | 15.87 | 3.047 |
| 11 | N. M. C. | HAVRE | SCHOOL | 526214 | 7154 | 64765 | 1358 | 0 | 62921 | 119573 | 16.71 | 3.915 |
| 12 | PINE HILLS | MILES CITY | SCHOOL | 165968 | 7205 | 35010 | 884 | 0 | 34524 | 208014 | 28.87 | 2.148 |
| 13 | SWAN RIVER | SWAN LAKE | MISC | 22038 | 7966 | 0 | 506 | 4760 | 6487 | 294347 | 36.95 | .404 |
| 14 | U. OF M. | MISSOULA | SCHOOL | 2214121 | 7362 | 283321 | 17111 | 0 | 313371 | 141533 | 19.22 | 19.497 |
| 15 | VET. HOME | COLUMBIA FA | APT CMPLX | 88650 | 7848 | 19289 | 565 | 0 | 19289 | 217568 | 27.72 | 1.200 |
| 16 | W. M. C. | DILLON | SCHOOL | 451184 | 7875 | 62441 | 1877 | 0 | 62601 | 138747 | 17.62 | 3.895 |
| 17 | WRM SPRNGS | WARM SPRING | HOSPITAL | 632729 | 8013 | 201938 | 0 | 1605 | 183349 | 289775 | 36.16 | 11.407 |

# ENERGY USAGE LISTING
## LISTED IN DECREASING ORDER OF % OF TOTAL BUILDING ENERGY CONSUMED

| NO. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | USAGE OF ENERGY BTU/GSF /YR | BTU/GSF /DD | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | M. S. U. | BOZEMAN | SCHOOL | 2549635 | 7278 | 441505 | 16178 | 0 | 452553 | 177497 | 24.39 | 28.156 |
| 2 | U. OF M. | MISSOULA | SCHOOL | 2214121 | 7362 | 283321 | 17111 | 0 | 313371 | 141533 | 19.22 | 19.497 |
| 3 | WRM SPRNGS | WARM SPRING | HOSPITAL | 632729 | 8013 | 201938 | 0 | 1605 | 183349 | 289775 | 36.16 | 11.407 |
| 4 | BLDR RIVER | BOULDER | HOSPITAL | 381346 | 7683 | 129166 | 1360 | 0 | 120891 | 317012 | 41.26 | 7.521 |
| 5 | E. M. C. | BILLINGS | SCHOOL | 754323 | 6723 | 92100 | 7200 | 0 | 107456 | 142454 | 21.19 | 6.686 |
| 6 | GALEN | GALEN | HOSPITAL | 283349 | 8013 | 82151 | 1627 | 0 | 79488 | 280530 | 35.01 | 4.945 |
| 7 | CAPITOL | HELENA | OFFICE | 574420 | 7502 | 57904 | 5841 | 0 | 72042 | 125417 | 16.72 | 4.482 |
| 8 | N. M. C. | HAVRE | SCHOOL | 526214 | 7154 | 64765 | 1358 | 0 | 62921 | 119573 | 16.71 | 3.915 |
| 9 | W. M. C. | DILLON | SCHOOL | 451184 | 7875 | 62441 | 1877 | 0 | 62601 | 138747 | 17.62 | 3.895 |
| 10 | MT TECH | BUTTE | SCHOOL | 343575 | 8980 | 46961 | 1967 | 0 | 48977 | 142553 | 15.87 | 3.047 |
| 11 | PINE HILLS | MILES CITY | SCHOOL | 165968 | 7205 | 35010 | 884 | 0 | 34524 | 208014 | 28.87 | 2.148 |
| 12 | VET. HOME | COLUMBIA FA | APT CMPLX | 88658 | 7848 | 19289 | 565 | 0 | 19289 | 217568 | 27.72 | 1.200 |
| 13 | HM FR AGED | LEWISTOWN | APT CMPLX | 74764 | 7844 | 15403 | 376 | 0 | 15145 | 202572 | 25.83 | .942 |
| 14 | DF & BLND | GREAT FALLS | SCHOOL | 113629 | 6811 | 12768 | 852 | 0 | 14399 | 126723 | 18.61 | .896 |
| 15 | MNT. VIEW | HELENA | SCHOOL | 76757 | 7502 | 10277 | 341 | 0 | 10411 | 135641 | 18.08 | .648 |
| 16 | SWAN RIVER | SWAN LAKE | MISC | 22038 | 7966 | 0 | 506 | 4760 | 6487 | 294347 | 36.95 | .404 |
| 17 | EAST. CNTR | GLENDIVE | SCHOOL | 23786 | 7045 | 3248 | 138 | 0 | 3392 | 142622 | 20.24 | .211 |

# ENERGY USAGE LISTING
## LISTED IN DECREASING ORDER OF ENERGY USE PER FLOOR AREA PER DEGREE DAY

| O. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | USAGE OF ENERGY BTU/GSF /YR | BTU/GSF /DD | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | BLDR RIVER | BOULDER | HOSPITAL | 381346 | 7683 | 129166 | 1360 | 0 | 120891 | 317012 | 41.26 | 7.521 |
| 2 | SWAN RIVER | SWAN LAKE | MISC | 22038 | 7966 | 0 | 506 | 4760 | 6487 | 294347 | 36.95 | .404 |
| 3 | WRM SPRNGS | WARM SPRING | HOSPITAL | 632729 | 8013 | 201938 | 0 | 1605 | 183349 | 289775 | 36.16 | 11.407 |
| 4 | GALEN | GALEN | HOSPITAL | 283349 | 8013 | 82151 | 1627 | 0 | 79488 | 280530 | 35.01 | 4.945 |
| 5 | PINE HILLS | MILES CITY | SCHOOL | 165968 | 7205 | 35010 | 884 | 0 | 34524 | 208014 | 28.87 | 2.148 |
| 6 | VET. HOME | COLUMBIA FA | APT CMPLX | 88658 | 7848 | 19289 | 565 | 0 | 19289 | 217568 | 27.72 | 1.200 |
| 7 | HM FR AGED | LEWISTOWN | APT CMPLX | 74764 | 7844 | 15403 | 376 | 0 | 15145 | 202572 | 25.83 | .942 |
| 8 | M. S. U. | BOZEMAN | SCHOOL | 2549635 | 7278 | 441505 | 16178 | 0 | 452553 | 177497 | 24.39 | 28.156 |
| 9 | E. M. C. | BILLINGS | SCHOOL | 754323 | 6723 | 92100 | 7200 | 0 | 107456 | 142454 | 21.19 | 6.686 |
| 10 | EAST. CNTR | GLENDIVE | SCHOOL | 23786 | 7045 | 3248 | 138 | 0 | 3392 | 142622 | 20.24 | .211 |
| 11 | U. OF M. | MISSOULA | SCHOOL | 2214121 | 7362 | 283321 | 17111 | 0 | 313371 | 141533 | 19.22 | 19.497 |
| 12 | DF & BLND | GREAT FALLS | SCHOOL | 113629 | 6811 | 12768 | 852 | 0 | 14399 | 126723 | 18.61 | .896 |
| 13 | MNT. VIEW | HELENA | SCHOOL | 76757 | 7502 | 10277 | 341 | 0 | 10411 | 135641 | 18.08 | .648 |
| 14 | W. M. C. | DILLON | SCHOOL | 451184 | 7875 | 62441 | 1877 | 0 | 62601 | 138747 | 17.62 | 3.895 |
| 15 | CAPITOL | HELENA | OFFICE | 574420 | 7502 | 57904 | 5841 | 0 | 72042 | 125417 | 16.72 | 4.482 |
| 16 | N. M. C. | HAVRE | SCHOOL | 526214 | 7154 | 64765 | .1358 | 0 | 62921 | 119573 | 16.71 | 3.915 |
| 17 | MT TECH | BUTTE | SCHOOL | 343575 | 8980 | 46961 | 1967 | 0 | 48977 | 142553 | 15.87 | 3.047 |

ENERGY USAGE LISTING FOR SCHOOL BUILDINGS
LISTED IN DECREASING ORDER OF ENERGY USE PER FLOOR AREA PER DEGREE DAY

| NO. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | USAGE OF ENERGY BTU/GSF /YR | BTU/GSF /DD | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | PINE HILLS | MILES CITY | SCHOOL | 165968 | 7205 | 35010 | 884 | 0 | 34524 | 208014 | 28.87 | 2.148 |
| 2 | M. S. U. | BOZEMAN | SCHOOL | 2549635 | 7278 | 441505 | 16178 | 0 | 452553 | 177497 | 24.39 | 28.156 |
| 3 | E. M. C. | BILLINGS | SCHOOL | 754323 | 6723 | 92100 | 7200 | 0 | 107456 | 142454 | 21.19 | 6.686 |
| 4 | EAST. CNTR | GLENDIVE | SCHOOL | 23786 | 7045 | 3248 | 138 | 0 | 3392 | 142622 | 20.24 | .211 |
| 5 | U. OF M. | MISSOULA | SCHOOL | 2214121 | 7362 | 283321 | 17111 | 0 | 313371 | 141533 | 19.22 | 19.497 |
| 6 | DF & BLND | GREAT FALLS | SCHOOL | 113629 | 6811 | 12768 | 852 | 0 | 14399 | 126723 | 18.61 | .896 |
| 7 | MNT. VIEW | HELENA | SCHOOL | 76757 | 7502 | 10277 | 341 | 0 | 10411 | 135641 | 18.08 | .648 |
| 8 | W. M. C. | DILLON | SCHOOL | 451184 | 7875 | 62441 | 1877 | 0 | 62601 | 138747 | 17.62 | 3.895 |
| 9 | N. M. C. | HAVRE | SCHOOL | 526214 | 7154 | 64765 | 1358 | 0 | 62921 | 119573 | 16.71 | 3.915 |
| 10 | MT TECH | BUTTE | SCHOOL | 343575 | 8980 | 46961 | 1967 | 0 | 48977 | 142553 | 15.87 | 3.047 |
| | AVERAGE | | SCHOOL | 721919 | | | | | | 153841 | 21.42 | |

ENERGY USAGE LISTING FOR APT CMPLX BUILDINGS
LISTED IN DECREASING ORDER OF ENERGY USE PER FLOOR AREA PER DEGREE DAY

| O. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | USAGE OF ENERGY BTU/GSF /YR | BTU/GSF /DD | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | VET. HOME | COLUMBIA FA | APT CMPLX | 88658 | 7848 | 19289 | 565 | 0 | 19289 | 217568 | 27.72 | 1.200 |
| 2 | HM FR AGED | LEWISTOWN | APT CMPLX | 74764 | 7844 | 15403 | 376 | 0 | 15145 | 202572 | 25.83 | .942 |
| | AVERAGE | | APT CMPLX | 81711 | | | | | | 210707 | 26.89 | |

ENERGY USAGE LISTING FOR HOSPITAL BUILDINGS
LISTED IN DECREASING ORDER OF ENERGY USE PER FLOOR AREA PER DEGREE DAY

| NO. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | USAGE OF ENERGY BTU/GSF /YR | BTU/GSF /DD | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | BLDR RIVER | BOULDER | HOSPITAL | 381346 | 7683 | 129166 | 1360 | 0 | 120891 | 317012 | 41.26 | 7.521 |
| 2 | WRM SPRNGS | WARM SPRING | HOSPITAL | 632729 | 8013 | 201938 | 0 | 1605 | 183349 | 289775 | 36.16 | 11.407 |
| 3 | GALEN | GALEN | HOSPITAL | 283349 | 8013 | 82151 | 1627 | 0 | 79488 | 280530 | 35.01 | 4.945 |
| | AVERAGE | | HOSPITAL | 432475 | | | | | | 295762 | 37.53 | |

ENERGY USAGE LISTING FOR OFFICE BUILDINGS
LISTED IN DECREASING ORDER OF ENERGY USE PER FLOOR AREA PER DEGREE DAY

| NO. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | USAGE OF ENERGY BTU/GSF /YR | BTU/GSF /DD | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | CAPITOL | HELENA | OFFICE | 574420 | 7502 | 57904 | 5841 | 0 | 72042 | 125417 | 16.72 | 4.482 |
| | AVERAGE | | OFFICE | 574420 | | | | | | 125417 | 16.72 | |

ENERGY USAGE LISTING FOR MISC BUILDINGS
LISTED IN DECREASING ORDER OF ENERGY USE PER FLOOR AREA PER DEGREE DAY

| ID. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | USAGE OF ENERGY BTU/GSF /YR | BTU/GSF /DD | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | SWAN RIVER | SWAN LAKE | MISC | 22038 | 7966 | 0 | 506 | 4760 | 6487 | 294347 | 36.95 | .404 |
| | AVERAGE | | MISC | 22038 | | | | | | 294347 | 36.95 | |

# E N E R G Y  A U D I T  S U M M A R Y  1976

GENERAL DATA:

| | |
|---|---|
| NUMBER OF INSTITUTIONS IN AUDIT | 17 |
| TOTAL GROSS FLOOR AREA (SQUARE FEET) | 9276496 |

BUILDING FUELS:

| | |
|---|---|
| NATURAL GAS CONSUMPTION (MCF) | 1558246 |
| OTHER FUEL CONSUMPTION (MMBTU) | 6365 |

ELECTRICITY:

| | |
|---|---|
| ELECTRICAL CONSUMPTION (MKWH) | 58180 |

TOTAL ENERGY:

| | |
|---|---|
| TOTAL ENERGY CONSUMPTION (MMBTU) | 1607297 |

ENERGY USAGE

| | | |
|---|---|---|
| BTU/GSF/YR | = | 173265 |
| BTU/GSF/DD | = | 25.24 |

# E N E R G Y  A U D I T  1977

FOR

ENERGY CONSERVATION STUDY

MONTANA

JANUARY 5, 1979

BY

DRAPES ENGINEERING
202 EKLUND BUILDING
GREAT FALLS, MONTANA

JOB NO. 77129

# DESCRIPTION OF OUTPUT LISTING

LOCATION: CITY NAME, (MONTANA ASSUMED AS THE STATE, UNLESS SPECIFIED OTHERWISE).

BUILDING TYPE: DESCRIBES MAJOR USE OF FACILITY.

BUILDING AREA: TOTAL AREA OF ALL FLOORS, IN GROSS SQUARE FEET (GSF).

HEATING DEGREE DAYS: ANNUAL TOTAL OF DIFFERENCE BETWEEN DAILY MEAN TEMP. AND 65 °F.

ENERGY CONSUMPTION: BASED ON UTILITY BILLING RECORDS.

GAS: AMOUNT USED DURING THE YEAR, IN THOUSANDS OF CUBIC FEET, (MCF).

ELECTRIC: AMOUNT USED DURING THE YEAR, INDICATED IN THOUSANDS OF KWH, (MKWH).

OTHER: ANY OTHER ENERGY SOURCE,LISTED BY ENERGY CONTENT IN MILLIONS OF BTU, (MMBTU).

TOTAL: AMOUNT OF ENERGY USED DURING AUDIT YEAR, IN MILLIONS OF BTU, (MMBTU).

USAGE OF ENERGY:

BTU/GSF-YR IS A PARAMETER PROVIDING A COMMON BASIS OF COMPARISON OF ENERGY USAGE FOR BUILDINGS HAVING SIMILAR CLIMATIC CONDITIONS. 'AVERAGE' VALUES OF THIS PARAMETER ARE COMPUTED AS THE RATIO OF THE TOTAL ENERGY USED TO THE TOTAL GROSS FLOOR AREA.

BTU/GSF-DEG.DAY IS A PARAMETER PROVIDING A COMMON BASIS OF COMPARISON OF BUILDING ENERGY USAGE REGARDLESS OF CLIMATE OR YEAR. 'AVERAGE' VALUES OF THIS PARAMETER ARE WEIGHTED AVERAGES, WEIGHTED BY THE OF TOTAL ENERGY USE.

# ALPHABETIC LISTING

| NO. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION | | | | USAGE OF ENERGY | | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | BTU/GSF /YR | BTU/GSF /DD | |
| 1 | BLDR RIVER | BOULDER | HOSPITAL | 375283 | 8010 | 117313 | 1267 | 0 | 109904 | 292856 | 36.56 | 7.042 |
| 2 | CAPITOL | HELENA | OFFICE | 630180 | 7766 | 48810 | 5758 | 0 | 63575 | 100884 | 12.99 | 4.073 |
| 3 | DF & BLND | GREAT FALLS | SCHOOL | 113629 | 7511 | 12200 | 761 | 0 | 13578 | 119491 | 15.91 | .870 |
| 4 | E. M. C. | BILLINGS | SCHOOL | 754323 | 6927 | 88700 | 7770 | 0 | 106341 | 140976 | 20.35 | 6.813 |
| 5 | EAST. CNTR | GLENDIVE | SCHOOL | 23786 | 7324 | 3406 | 138 | 0 | 3535 | 148601 | 20.29 | .226 |
| 6 | GALEN | GALEN | HOSPITAL | 283349 | 8164 | 75470 | 1571 | 0 | 73283 | 258630 | 31.68 | 4.695 |
| 7 | HM FR AGED | LEWISTOWN | APT CMPLX | 74764 | 8651 | 17651 | 486 | 0 | 17546 | 234682 | 27.13 | 1.124 |
| 8 | M. S. U. | BOZEMAN | SCHOOL | 2549635 | 7537 | 430027 | 17330 | 0 | 446154 | 174987 | 23.22 | 28.586 |
| 9 | MNT. VIEW | HELENA | SCHOOL | 76757 | 7766 | 10119 | 320 | 0 | 10200 | 132886 | 17.11 | .654 |
| 10 | MT TECH | BUTTE | SCHOOL | 343575 | 9774 | 45197 | 2064 | 0 | 47719 | 138890 | 14.21 | 3.057 |
| 11 | N. M. C. | HAVRE | SCHOOL | 526214 | 7983 | 71596 | 1511 | 0 | 69591 | 132248 | 16.57 | 4.459 |
| 12 | PINE HILLS | MILES CITY | SCHOOL | 165968 | 7582 | 32853 | 822 | 0 | 32372 | 195049 | 25.73 | 2.074 |
| 13 | SWAN RIVER | SWAN LAKE | MISC | 22038 | 8284 | 0 | 608 | 4760 | 6836 | 310176 | 37.44 | .438 |
| 14 | U. OF M. | MISSOULA | SCHOOL | 2175493 | 7689 | 254158 | 17242 | 0 | 287571 | 132186 | 17.19 | 18.425 |
| 15 | VET. HOME | COLUMBIA FA | APT CMPLX | 88658 | 8149 | 19984 | 543 | 0 | 19838 | 223762 | 27.46 | 1.271 |
| 16 | W. M. C. | DILLON | SCHOOL | 451184 | 8207 | 60418 | 1856 | 0 | 60708 | 134552 | 16.39 | 3.890 |
| 17 | WRM SPRNGS | WARM SPRING | HOSPITAL | 611487 | 8164 | 196143 | 4534 | 0 | 192000 | 313989 | 38.46 | 12.302 |

# ENERGY USAGE LISTING
## LISTED IN DECREASING ORDER OF % OF TOTAL BUILDING ENERGY CONSUMED

| O. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | USAGE OF ENERGY BTU/GSF /YR | BTU/GSF /DD | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | M. S. U. | BOZEMAN | SCHOOL | 2549635 | 7537 | 430027 | 17330 | 0 | 446154 | 174987 | 23.22 | 28.586 |
| 2 | U. OF M. | MISSOULA | SCHOOL | 2175493 | 7689 | 254158 | 17242 | 0 | 287571 | 132186 | 17.19 | 18.425 |
| 3 | WRM SPRNGS | WARM SPRING | HOSPITAL | 611487 | 8164 | 196143 | 4534 | 0 | 192000 | 313989 | 38.46 | 12.302 |
| 4 | BLDR RIVER | BOULDER | HOSPITAL | 375283 | 8010 | 117313 | 1267 | 0 | 109904 | 292856 | 36.56 | 7.042 |
| 5 | E. M. C. | BILLINGS | SCHOOL | 754323 | 6927 | 88700 | 7770 | 0 | 106341 | 140976 | 20.35 | 6.813 |
| 6 | GALEN | GALEN | HOSPITAL | 283349 | 8164 | 75470 | 1571 | 0 | 73283 | 258630 | 31.68 | 4.695 |
| 7 | N. M. C. | HAVRE | SCHOOL | 526214 | 7983 | 71596 | 1511 | 0 | 69591 | 132248 | 16.57 | 4.459 |
| 8 | CAPITOL | HELENA | OFFICE | 630180 | 7766 | 48810 | 5758 | 0 | 63575 | 100884 | 12.99 | 4.073 |
| 9 | W. M. C. | DILLON | SCHOOL | 451184 | 8207 | 60418 | 1856 | 0 | 60708 | 134552 | 16.39 | 3.890 |
| 10 | MT TECH | BUTTE | SCHOOL | 343575 | 9774 | 45197 | 2064 | 0 | 47719 | 138890 | 14.21 | 3.057 |
| 11 | PINE HILLS | MILES CITY | SCHOOL | 165968 | 7582 | 32853 | 822 | 0 | 32372 | 195049 | 25.73 | 2.074 |
| 12 | VET. HOME | COLUMBIA FA | APT CMPLX | 88658 | 8149 | 19984 | 543 | 0 | 19838 | 223762 | 27.46 | 1.271 |
| 13 | HM FR AGED | LEWISTOWN | APT CMPLX | 74764 | 8651 | 17651 | 486 | 0 | 17546 | 234682 | 27.13 | 1.124 |
| 14 | DF & BLND | GREAT FALLS | SCHOOL | 113629 | 7511 | 12200 | 761 | 0 | 13578 | 119491 | 15.91 | .870 |
| 15 | MNT. VIEW | HELENA | SCHOOL | 76757 | 7766 | 10119 | 320 | 0 | 10200 | 132886 | 17.11 | .654 |
| 16 | SWAN RIVER | SWAN LAKE | MISC | 22038 | 8284 | 0 | 608 | 4760 | 6836 | 310176 | 37.44 | .438 |
| 17 | EAST. CNTR | GLENDIVE | SCHOOL | 23786 | 7324 | 3406 | 138 | 0 | 3535 | 148601 | 20.29 | .226 |

# ENERGY USAGE LISTING
## LISTED IN DECREASING ORDER OF ENERGY USE PER FLOOR AREA PER DEGREE DAY

| NO. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION | | | | USAGE OF ENERGY | | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | BTU/GSF /YR | BTU/GSF /DD | |
| 1 | WRM SPRNGS | WARM SPRING | HOSPITAL | 611487 | 8164 | 196143 | 4534 | 0 | 192000 | 313989 | 38.46 | 12.302 |
| 2 | SWAN RIVER | SWAN LAKE | MISC | 22038 | 8284 | 0 | 608 | 4760 | 6836 | 310176 | 37.44 | .438 |
| 3 | BLDR RIVER | BOULDER | HOSPITAL | 375283 | 8010 | 117313 | 1267 | 0 | 109904 | 292856 | 36.56 | 7.042 |
| 4 | GALEN | GALEN | HOSPITAL | 283349 | 8164 | 75470 | 1571 | 0 | 73283 | 258630 | 31.68 | 4.695 |
| 5 | VET. HOME | COLUMBIA FA | APT CMPLX | 88658 | 8149 | 19984 | 543 | 0 | 19838 | 223762 | 27.46 | 1.271 |
| 6 | HM FR AGED | LEWISTOWN | APT CMPLX | 74764 | 8651 | 17651 | 486 | 0 | 17546 | 234682 | 27.13 | 1.124 |
| 7 | PINE HILLS | MILES CITY | SCHOOL | 165968 | 7582 | 32853 | 822 | 0 | 32372 | 195049 | 25.73 | 2.074 |
| 8 | M. S. U. | BOZEMAN | SCHOOL | 2549635 | 7537 | 430027 | 17330 | 0 | 446154 | 174987 | 23.22 | 28.586 |
| 9 | E. M. C. | BILLINGS | SCHOOL | 754323 | 6927 | 88700 | 7770 | 0 | 106341 | 140976 | 20.35 | 6.813 |
| 10 | EAST. CNTR | GLENDIVE | SCHOOL | 23786 | 7324 | 3406 | 138 | 0 | 3535 | 148601 | 20.29 | .226 |
| 11 | U. OF M. | MISSOULA | SCHOOL | 2175493 | 7689 | 254158 | 17242 | 0 | 287571 | 132186 | 17.19 | 18.425 |
| 12 | MNT. VIEW | HELENA | SCHOOL | 76757 | 7766 | 10119 | 320 | 0 | 10200 | 132886 | 17.11 | .654 |
| 13 | N. M. C. | HAVRE | SCHOOL | 526214 | 7983 | 71596 | 1511 | 0 | 69591 | 132248 | 16.57 | 4.459 |
| 14 | W. M. C. | DILLON | SCHOOL | 451184 | 8207 | 60418 | 1856 | 0 | 60708 | 134552 | 16.39 | 3.890 |
| 15 | DF & BLND | GREAT FALLS | SCHOOL | 113629 | 7511 | 12200 | 761 | 0 | 13578 | 119491 | 15.91 | .870 |
| 16 | MT TECH | BUTTE | SCHOOL | 343575 | 9774 | 45197 | 2064 | 0 | 47719 | 138890 | 14.21 | 3.057 |
| 17 | CAPITOL | HELENA | OFFICE | 630180 | 7766 | 48810 | 5758 | 0 | 63575 | 100884 | 12.99 | 4.073 |

ENERGY USAGE LISTING FOR SCHOOL BUILDINGS
LISTED IN DECREASING ORDER OF ENERGY USE PER FLOOR AREA PER DEGREE DAY

| ID. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | USAGE OF ENERGY BTU/GSF /YR | BTU/GSF /DD | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | PINE HILLS | MILES CITY | SCHOOL | 165968 | 7582 | 32853 | 822 | 0 | 32372 | 195049 | 25.73 | 2.074 |
| 2 | M. S. U. | BOZEMAN | SCHOOL | 2549635 | 7537 | 430027 | 17330 | 0 | 446154 | 174987 | 23.22 | 28.586 |
| 3 | E. M. C. | BILLINGS | SCHOOL | 754323 | 6927 | 88700 | 7770 | 0 | 106341 | 140976 | 20.35 | 6.813 |
| 4 | EAST. CNTR | GLENDIVE | SCHOOL | 23786 | 7324 | 3406 | 138 | 0 | 3535 | 148601 | 20.29 | .226 |
| 5 | U. OF M. | MISSOULA | SCHOOL | 2175493 | 7689 | 254158 | 17242 | 0 | 287571 | 132186 | 17.19 | 18.425 |
| 6 | MNT. VIEW | HELENA | SCHOOL | 76757 | 7766 | 10119 | 320 | 0 | 10200 | 132886 | 17.11 | .654 |
| 7 | N. M. C. | HAVRE | SCHOOL | 526214 | 7983 | 71596 | 1511 | 0 | 69591 | 132248 | 16.57 | 4.459 |
| 8 | W. M. C. | DILLON | SCHOOL | 451184 | 8207 | 60418 | 1856 | 0 | 60708 | 134552 | 16.39 | 3.890 |
| 9 | DF & BLND | GREAT FALLS | SCHOOL | 113629 | 7511 | 12200 | 761 | 0 | 13578 | 119491 | 15.91 | .870 |
| 10 | MT TECH | BUTTE | SCHOOL | 343575 | 9774 | 45197 | 2064 | 0 | 47719 | 138890 | 14.21 | 3.057 |
| | AVERAGE | | SCHOOL | 718056 | | | | | | 150095 | 20.03 | |

ENERGY USAGE LISTING FOR APT CMPLX BUILDINGS
LISTED IN DECREASING ORDER OF ENERGY USE PER FLOOR AREA PER DEGREE DAY

| NO. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | USAGE OF ENERGY BTU/GSF /YR | BTU/GSF /DD | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | VET. HOME | COLUMBIA FA | APT CMPLX | 88658 | 8149 | 19984 | 543 | 0 | 19838 | 223762 | 27.46 | 1.271 |
| 2 | HM FR AGED | LEWISTOWN | APT CMPLX | 74764 | 8651 | 17651 | 486 | 0 | 17546 | 234682 | 27.13 | 1.124 |
| | AVERAGE | | APT CMPLX | 81711 | | | | | | 228758 | 27.30 | |

ENERGY USAGE LISTING FOR HOSPITAL BUILDINGS
LISTED IN DECREASING ORDER OF ENERGY USE PER FLOOR AREA PER DEGREE DAY

| NO. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | USAGE OF ENERGY BTU/GSF /YR | BTU/GSF /DD | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | WRM SPRNGS | WARM SPRING | HOSPITAL | 611487 | 8164 | 196143 | 4534 | 0 | 192000 | 313989 | 38.46 | 12.302 |
| 2 | BLDR RIVER | BOULDER | HOSPITAL | 375283 | 8010 | 117313 | 1267 | 0 | 109904 | 292856 | 36.56 | 7.042 |
| 3 | GALEN | GALEN | HOSPITAL | 283349 | 8164 | 75470 | 1571 | 0 | 73283 | 258630 | 31.68 | 4.695 |
| | AVERAGE | | HOSPITAL | 423373 | | | | | | 295395 | 36.58 | |

ENERGY USAGE LISTING FOR OFFICE BUILDINGS
LISTED IN DECREASING ORDER OF ENERGY USE PER FLOOR AREA PER DEGREE DAY

| NO. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | USAGE OF ENERGY BTU/GSF /YR | BTU/GSF /DD | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | CAPITOL | HELENA | OFFICE | 630180 | 7766 | 48810 | 5758 | 0 | 63575 | 100884 | 12.99 | 4.073 |
| | AVERAGE | | OFFICE | 630180 | | | | | | 100884 | 12.99 | |

ENERGY USAGE LISTING FOR MISC BUILDINGS
LISTED IN DECREASING ORDER OF ENERGY USE PER FLOOR AREA PER DEGREE DAY

| O. | NAME | LOCATION | BUILDING TYPE | BLDG. AREA (GSF) | HEATING DEGREE DAYS | ENERGY CONSUMPTION | | | | USAGE OF ENERGY | | % OF TOTAL USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | GAS (MCF) | ELECTRIC (MKWH) | OTHER (MMBTU) | TOTAL (MMBTU) | BTU/GSF /YR | BTU/GSF /DD | |
| 1 | SWAN RIVER | SWAN LAKE | MISC | 22038 | 8284 | 0 | 608 | 4760 | 6836 | 310176 | 37.44 | .438 |
| | AVERAGE | | MISC | 22038 | | | | | | 310176 | 37.44 | |

# E N E R G Y  A U D I T  S U M M A R Y  1977

GENERAL DATA:

| | |
|---|---|
| NUMBER OF INSTITUTIONS IN AUDIT | 17 |
| TOTAL GROSS FLOOR AREA (SQUARE FEET) | 9266323 |

BUILDING FUELS:

| | |
|---|---|
| NATURAL GAS CONSUMPTION (MCF) | 1484044 |
| OTHER FUEL CONSUMPTION (MMBTU) | 4760 |

ELECTRICITY:

| | |
|---|---|
| ELECTRICAL CONSUMPTION (MKWH) | 64580 |

TOTAL ENERGY:

| | |
|---|---|
| TOTAL ENERGY CONSUMPTION (MMBTU) | 1560748 |

ENERGY USAGE

| | | |
|---|---|---|
| BTU/GSF/YR | = | 168432 |
| BTU/GSF/DD | = | 23.97 |

# G E N E R A L  E N E R G Y  A U D I T

# Y E A R L Y  C O M P A R I S O N

FOR
STATE OF MONTANA
HELENA, MT

JANUARY 8, 1979

BY
DRAPES ENGINEERING
202 EKLUND BUILDING
GREAT FALLS, MONTANA

JOB NO. 77129

## DESCRIPTION OF OUTPUT LISTING

LOCATION: CITY NAME (MONTANA ASSSUMED AS THE STATE UNLESS SPECIFIED OTHERWISE.)

BUILDING: DESCRIPTION OF MAJOR USE OF FACILITY.

USAGE OF ENERGY: BTU/GSF-DD (BTU PER GROSS SQUARE FOOT OF BUILDING FLOOR AREA PER DEGREE DAY) IS A PARAMETER PROVIDING A COMMON BASIS OF COMPARISON OF BUILDING ENERGY USAGE REGARDLESS OF CLIMATE OR YEAR.

PERCENT CHANGE FROM PREVIOUS YEAR: NEGATIVE VALUE INDICATES THAT USAGE OF ENERGY DECREASED FROM PREVIOUS YEAR. POSITIVE VALUE INDICATES THAT USAGE OF ENERGY INCREASED FROM PREVIOUS YEAR.

# ENERGY USAGE FOR ALL BUILDINGS
## ALPHABETIC LISTING

| O. | NAME | LOCATION | BUILDING TYPE | BTU/ GSF-DD 1973 | BTU/ GSF-DD 1974 | % CHANGE FROM 1973 | BTU/ GSF-DD 1975 | % CHANGE FROM 1974 | BTU/ GSF-DD 1976 | % CHANGE FROM 1975 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | BLDR RIVER | BOULDER | HOSPITAL | 40.92 | 37.98 | - 7.20% | 38.59 | 1.60% | 41.26 | 6.93% |
| 2 | CAPITOL | HELENA | OFFICE | 15.67 | 17.76 | 13.37% | 15.35 | -13.55% | 16.72 | 8.89% |
| 3 | DF & BLND | GREAT FALLS | SCHOOL | 18.56 | 20.04 | 8.00% | 16.98 | -15.29% | 18.61 | 9.60% |
| 4 | E. M. C. | BILLINGS | SCHOOL | 23.29 | 22.05 | - 5.31% | 18.74 | -15.00% | 21.19 | 13.04% |
| 5 | EAST. CNTR | GLENDIVE | SCHOOL | 21.12 | 20.35 | - 3.65% | 19.99 | - 1.79% | 20.24 | 1.28% |
| 6 | GALEN | GALEN | HOSPITAL | 34.55 | 33.91 | - 1.85% | 33.31 | - 1.75% | 35.01 | 5.09% |
| 7 | HM FR AGED | LEWISTOWN | APT CMPLX | 32.97 | 31.72 | - 3.77% | 25.93 | -18.26% | 25.83 | - .41% |
| 8 | M. S. U. | BOZEMAN | SCHOOL | 26.49 | 28.05 | 5.90% | 22.11 | -21.17% | 24.39 | 10.29% |
| 9 | MNT. VIEW | HELENA | SCHOOL | 17.77 | 19.06 | 7.29% | 16.21 | -14.93% | 18.08 | 11.51% |
| 10 | MT TECH | BUTTE | SCHOOL | 17.36 | 17.99 | 3.59% | 13.72 | -23.72% | 15.87 | 15.71% |
| 11 | N. M. C. | HAVRE | SCHOOL | 17.11 | 18.23 | 6.56% | 17.41 | - 4.53% | 16.71 | - 3.97% |
| 12 | PINE HILLS | MILES CITY | SCHOOL | 31.37 | 28.94 | - 7.75% | 27.45 | - 5.14% | 28.87 | 5.18% |
| 13 | SWAN RIVER | SWAN LAKE | MISC. | 31.97 | 34.03 | 6.46% | 32.67 | - 3.99% | 36.95 | 13.10% |
| 14 | U. OF M. | MISSOULA | SCHOOL | 24.01 | 22.05 | - 8.15% | 18.78 | -14.82% | 19.22 | 2.36% |
| 15 | VET. HOME | COLUMBIA FA | APT CMPLX | 26.74 | 31.37 | 17.29% | 26.88 | -14.30% | 27.72 | 3.14% |
| 16 | W. M. C. | DILLON | SCHOOL | 20.50 | 20.00 | - 2.44% | 18.36 | - 8.21% | 17.62 | - 4.05% |
| 17 | WRM SPRNGS | WARM SPRING | HOSPITAL | 39.65 | 40.49 | 2.11% | 35.41 | -12.54% | 36.16 | 2.13% |

ENERGY USAGE LISTING FOR ALL BUILDINGS
LISTED IN INCREASING PERCENT CHANGE FROM 1975

| O. | NAME | LOCATION | BUILDING TYPE | BTU/ GSF-DD 1973 | BTU/ GSF-DD 1974 | % CHANGE FROM 1973 | BTU/ GSF-DD 1975 | % CHANGE FROM 1974 | BTU/ GSF-DD 1976 | % CHANGE FROM 1975 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | W. M. C. | DILLON | SCHOOL | 20.50 | 20.00 | - 2.44% | 18.36 | - 8.21% | 17.62 | - 4.05% |
| 2 | N. M. C. | HAVRE | SCHOOL | 17.11 | 18.23 | 6.56% | 17.41 | - 4.53% | 16.71 | - 3.97% |
| 3 | HM FR AGED | LEWISTOWN | APT CMPLX | 32.97 | 31.72 | - 3.77% | 25.93 | -18.26% | 25.83 | - .41% |
| 4 | EAST. CNTR | GLENDIVE | SCHOOL | 21.12 | 20.35 | - 3.65% | 19.99 | - 1.79% | 20.24 | 1.28% |
| 5 | WRM SPRNGS | WARM SPRING | HOSPITAL | 39.65 | 40.49 | 2.11% | 35.41 | -12.54% | 36.16 | 2.13% |
| 6 | U. OF M. | MISSOULA | SCHOOL | 24.01 | 22.05 | - 8.15% | 18.78 | -14.82% | 19.22 | 2.36% |
| 7 | VET. HOME | COLUMBIA FA | APT CMPLX | 26.74 | 31.37 | 17.29% | 26.88 | -14.30% | 27.72 | 3.14% |
| 8 | GALEN | GALEN | HOSPITAL | 34.55 | 33.91 | - 1.85% | 33.31 | - 1.75% | 35.01 | 5.09% |
| 9 | PINE HILLS | MILES CITY | SCHOOL | 31.37 | 28.94 | - 7.75% | 27.45 | - 5.14% | 28.87 | 5.18% |
| 10 | BLDR RIVER | BOULDER | HOSPITAL | 40.92 | 37.98 | - 7.20% | 38.59 | 1.60% | 41.26 | 6.93% |
| 11 | CAPITOL | HELENA | OFFICE | 15.67 | 17.76 | 13.37% | 15.35 | -13.55% | 16.72 | 8.89% |
| 12 | DF & BLND | GREAT FALLS | SCHOOL | 18.56 | 20.04 | 8.00% | 16.98 | -15.29% | 18.61 | 9.60% |
| 13 | M. S. U. | BOZEMAN | SCHOOL | 26.49 | 28.05 | 5.90% | 22.11 | -21.17% | 24.39 | 10.29% |
| 14 | MNT. VIEW | HELENA | SCHOOL | 17.77 | 19.06 | 7.29% | 16.21 | -14.93% | 18.08 | 11.51% |
| 15 | E. M. C. | BILLINGS | SCHOOL | 23.29 | 22.05 | - 5.31% | 18.74 | -15.00% | 21.19 | 13.04% |
| 16 | SWAN RIVER | SWAN LAKE | MISC. | 31.97 | 34.03 | 6.46% | 32.67 | - 3.99% | 36.95 | 13.10% |
| 17 | MT TECH | BUTTE | SCHOOL | 17.36 | 17.99 | 3.59% | 13.72 | -23.72% | 15.87 | 15.71% |
| | AVERAGE | | | 27.71 | 27.44 | - .99% | 23.92 | -12.84% | 25.24 | 5.52% |

ENERGY USAGE LISTING FOR SCHOOL BUILDINGS
LISTED IN INCREASING PERCENT CHANGE FROM 1975

| O. | NAME | LOCATION | BUILDING TYPE | BTU/ GSF-DD 1973 | BTU/ GSF-DD 1974 | % CHANGE FROM 1973 | BTU/ GSF-DD 1975 | % CHANGE FROM 1974 | BTU/ GSF-DD 1976 | % CHANGE FROM 1975 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | W. M. C. | DILLON | SCHOOL | 20.50 | 20.00 | - 2.44% | 18.36 | - 8.21% | 17.62 | - 4.05% |
| 2 | N. M. C. | HAVRE | SCHOOL | 17.11 | 18.23 | 6.56% | - 17.41 | - 4.53% | 16.71 | - 3.97% |
| 3 | EAST. CNTR | GLENDIVE | SCHOOL | 21.12 | 20.35 | - 3.65% | 19.99 | - 1.79% | 20.24 | 1.28% |
| 4 | U. OF M. | MISSOULA | SCHOOL | 24.01 | 22.05 | - 8.15% | 18.78 | -14.82% | 19.22 | 2.36% |
| 5 | PINE HILLS | MILES CITY | SCHOOL | 31.37 | 28.94 | - 7.75% | 27.45 | - 5.14% | 28.87 | 5.18% |
| 6 | DF & BLND | GREAT FALLS | SCHOOL | 18.56 | 20.04 | 8.00% | 16.98 | -15.29% | 18.61 | 9.60% |
| 7 | M. S. U. | BOZEMAN | SCHOOL | 26.49 | 28.05 | 5.90% | 22.11 | -21.17% | 24.39 | 10.29% |
| 8 | MNT. VIEW | HELENA | SCHOOL | 17.77 | 19.06 | 7.29% | 16.21 | -14.93% | 18.08 | 11.51% |
| 9 | E. M. C. | BILLINGS | SCHOOL | 23.29 | 22.05 | - 5.31% | 18.74 | -15.00% | 21.19 | 13.04% |
| 10 | MT TECH | BUTTE | SCHOOL | 17.36 | 17.99 | 3.59% | 13.72 | -23.72% | 15.87 | 15.71% |
| | AVERAGE | | | 24.07 | 23.95 | - .49% | 19.95 | -16.71% | 21.42 | 7.39% |

ENERGY USAGE LISTING FOR APT CMPLX BUILDINGS
LISTED IN INCREASING PERCENT CHANGE FROM 1975

| O. | NAME | LOCATION | BUILDING TYPE | BTU/ GSF-DD 1973 | BTU/ GSF-DD 1974 | % CHANGE FROM 1973 | BTU/ GSF-DD 1975 | % CHANGE FROM 1974 | BTU/ GSF-DD 1976 | % CHANGE FROM 1975 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | HM FR AGED | LEWISTOWN | APT CMPLX | 32.97 | 31.72 | - 3.77% | 25.93 | -18.26% | 25.83 | - .41% |
| 2 | VET. HOME | COLUMBIA FA | APT CMPLX | 26.74 | 31.37 | 17.29% | 26.88 | -14.30% | 27.72 | 3.14% |
| | AVERAGE | | | 29.48 | 31.51 | 6.87% | 26.50 | -15.90% | 26.89 | 1.47% |

ENERGY USAGE LISTING FOR HOSPITAL BUILDINGS
LISTED IN INCREASING PERCENT CHANGE FROM 1975

| O. | NAME | LOCATION | BUILDING TYPE | BTU/ GSF-DD 1973 | BTU/ GSF-DD 1974 | % CHANGE FROM 1973 | BTU/ GSF-DD 1975 | % CHANGE FROM 1974 | BTU/ GSF-DD 1976 | % CHANGE FROM 1975 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | WRM SPRNGS | WARM SPRING | HOSPITAL | 39.65 | 40.49 | 2.11% | 35.41 | -12.54% | 36.16 | 2.13% |
| 2 | GALEN | GALEN | HOSPITAL | 34.55 | 33.91 | - 1.85% | - 33.31 | - 1.75% | 35.01 | 5.09% |
| 3 | BLDR RIVER | BOULDER | HOSPITAL | 40.92 | 37.98 | - 7.20% | 38.59 | 1.60% | 41.26 | 6.93% |
| | AVERAGE | | | 39.12 | 38.49 | - 1.62% | 36.04 | - 6.37% | 37.53 | 4.14% |

ENERGY USAGE LISTING FOR OFFICE BUILDINGS
LISTED IN INCREASING PERCENT CHANGE FROM 1975

| O. | NAME | LOCATION | BUILDING TYPE | BTU/ GSF-DD 1973 | BTU/ GSF-DD 1974 | % CHANGE FROM 1973 | BTU/ GSF-DD 1975 | % CHANGE FROM 1974 | BTU/ GSF-DD 1976 | % CHANGE FROM 1975 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | CAPITOL | HELENA | OFFICE | 15.67 | 17.76 | 13.37% | 15.35 | -13.55% | 16.72 | 8.89% |
| | | AVERAGE | | 15.67 | 17.76 | 13.37% | 15.35 | -13.55% | 16.72 | 8.89% |

ENERGY USAGE LISTING FOR MISC. BUILDINGS
LISTED IN INCREASING PERCENT CHANGE FROM 1975

| O. | NAME | LOCATION | BUILDING TYPE | BTU/ GSF-DD 1973 | BTU/ GSF-DD 1974 | % CHANGE FROM 1973 | BTU/ GSF-DD 1975 | % CHANGE FROM 1974 | BTU/ GSF-DD 1976 | % CHANGE FROM 1975 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | SWAN RIVER | SWAN LAKE | MISC. | 31.97 | 34.03 | 6.46% | 32.67 | - 3.99% | 36.95 | 13.10% |
| | AVERAGE | | | 31.97 | 34.03 | 6.46% | 32.67 | - 3.99% | 36.95 | 13.10% |

# G E N E R A L  E N E R G Y  A U D I T

# Y E A R L Y  C O M P A R I S O N

FOR
STATE OF MONTANA
HELENA, MT

JANUARY 10, 1979

BY
DRAPES ENGINEERING
202 EKLUND BUILDING
GREAT FALLS, MONTANA

JOB NO. 77129

# DESCRIPTION OF OUTPUT LISTING

LOCATION: CITY NAME (MONTANA ASSSUMED AS THE STATE UNLESS SPECIFIED OTHERWISE.)

BUILDING: DESCRIPTION OF MAJOR USE OF FACILITY.

USAGE OF ENERGY: BTU/GSF-DD (BTU PER GROSS SQUARE FOOT OF BUILDING FLOOR AREA PER DEGREE DAY) IS A PARAMETER PROVIDING A COMMON BASIS OF COMPARISON OF BUILDING ENERGY USAGE REGARDLESS OF CLIMATE OR YEAR.

PERCENT CHANGE FROM PREVIOUS YEAR: NEGATIVE VALUE INDICATES THAT USAGE OF ENERGY DECREASED FROM PREVIOUS YEAR. POSITIVE VALUE INDICATES THAT USAGE OF ENERGY INCREASED FROM PREVIOUS YEAR.

# ENERGY USAGE FOR ALL BUILDINGS
## ALPHABETIC LISTING

| NO. | NAME | LOCATION | BUILDING TYPE | BTU/ GSF-DD 1974 | BTU/ GSF-DD 1975 | % CHANGE FROM 1974 | BTU/ GSF-DD 1976 | % CHANGE FROM 1975 | BTU/ GSF-DD 1977 | % CHANGE FROM 1976 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | BLDR RIVER | BOULDER | HOSPITAL | 37.98 | 38.59 | 1.60% | 41.26 | 6.93% | 36.56 | -11.39% |
| 2 | CAPITOL | HELENA | OFFICE | 17.76 | 15.35 | -13.55% | 16.72 | 8.89% | 12.99 | -22.30% |
| 3 | DF & BLND | GREAT FALLS | SCHOOL | 20.04 | 16.98 | -15.29% | 18.61 | 9.60% | 15.91 | -14.49% |
| 4 | E. M. C. | BILLINGS | SCHOOL | 22.05 | 18.74 | -15.00% | 21.19 | 13.04% | 20.35 | - 3.95% |
| 5 | EAST. CNTR | GLENDIVE | SCHOOL | 20.35 | 19.99 | - 1.79% | 20.24 | 1.28% | 20.29 | .22% |
| 6 | GALEN | GALEN | HOSPITAL | 33.91 | 33.31 | - 1.75% | 35.01 | 5.09% | 31.68 | - 9.51% |
| 7 | HM FR AGED | LEWISTOWN | APT CMPLX | 31.72 | 25.93 | -18.26% | 25.83 | - .41% | 27.13 | 5.04% |
| 8 | M. S. U. | BOZEMAN | SCHOOL | 28.05 | 22.11 | -21.17% | 24.39 | 10.29% | 23.22 | - 4.80% |
| 9 | MNT. VIEW | HELENA | SCHOOL | 19.06 | 16.21 | -14.93% | 18.08 | 11.51% | 17.11 | - 5.36% |
| 10 | MT TECH | BUTTE | SCHOOL | 17.99 | 13.72 | -23.72% | 15.87 | 15.71% | 14.21 | -10.48% |
| 11 | N. M. C. | HAVRE | SCHOOL | 18.23 | 17.41 | - 4.53% | 16.71 | - 3.97% | 16.57 | - .89% |
| 12 | PINE HILLS | MILES CITY | SCHOOL | 28.94 | 27.45 | - 5.14% | 28.87 | 5.18% | 25.73 | -10.90% |
| 13 | SWAN RIVER | SWAN LAKE | MISC. | 34.03 | 32.67 | - 3.99% | 36.95 | 13.10% | 37.44 | 1.33% |
| 14 | U. OF M. | MISSOULA | SCHOOL | 22.05 | 18.78 | -14.82% | 19.22 | 2.36% | 17.19 | -10.58% |
| 15 | VET. HOME | COLUMBIA FA | APT CMPLX | 31.37 | 26.88 | -14.30% | 27.72 | 3.14% | 27.46 | - .95% |
| 16 | W. M. C. | DILLON | SCHOOL | 20.00 | 18.36 | - 8.21% | 17.62 | - 4.05% | 16.39 | - 6.95% |
| 17 | WRM SPRNGS | WARM SPRING | HOSPITAL | 40.49 | 35.41 | -12.54% | 36.16 | 2.13% | 38.46 | 6.35% |

ENERGY USAGE LISTING FOR ALL BUILDINGS
LISTED IN INCREASING PERCENT CHANGE FROM 1976

| NO. | NAME | LOCATION | BUILDING TYPE | BTU/ GSF-DD 1974 | BTU/ GSF-DD 1975 | % CHANGE FROM 1974 | BTU/ GSF-DD 1976 | % CHANGE FROM 1975 | BTU/ GSF-DD 1977 | % CHANGE FROM 1976 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | CAPITOL | HELENA | OFFICE | 17.76 | 15.35 | -13.55% | 16.72 | 8.89% | 12.99 | -22.30% |
| 2 | DF & BLND | GREAT FALLS | SCHOOL | 20.04 | 16.98 | -15.29% | 18.61 | 9.60% | 15.91 | -14.49% |
| 3 | BLDR RIVER | BOULDER | HOSPITAL | 37.98 | 38.59 | 1.60% | 41.26 | 6.93% | 36.56 | -11.39% |
| 4 | PINE HILLS | MILES CITY | SCHOOL | 28.94 | 27.45 | - 5.14% | 28.87 | 5.18% | 25.73 | -10.90% |
| 5 | U. OF M. | MISSOULA | SCHOOL | 22.05 | 18.78 | -14.82% | 19.22 | 2.36% | 17.19 | -10.58% |
| 6 | MT TECH | BUTTE | SCHOOL | 17.99 | 13.72 | -23.72% | 15.87 | 15.71% | 14.21 | -10.48% |
| 7 | GALEN | GALEN | HOSPITAL | 33.91 | 33.31 | - 1.75% | 35.01 | 5.09% | 31.68 | - 9.51% |
| 8 | W. M. C. | DILLON | SCHOOL | 20.00 | 18.36 | - 8.21% | 17.62 | - 4.05% | 16.39 | - 6.95% |
| 9 | MNT. VIEW | HELENA | SCHOOL | 19.06 | 16.21 | -14.93% | 18.08 | 11.51% | 17.11 | - 5.36% |
| 10 | M. S. U. | BOZEMAN | SCHOOL | 28.05 | 22.11 | -21.17% | 24.39 | 10.29% | 23.22 | - 4.80% |
| 11 | E. M. C. | BILLINGS | SCHOOL | 22.05 | 18.74 | -15.00% | 21.19 | 13.04% | 20.35 | - 3.95% |
| 12 | VET. HOME | COLUMBIA FA | APT CMPLX | 31.37 | 26.88 | -14.30% | 27.72 | 3.14% | 27.46 | - .95% |
| 13 | N. M. C. | HAVRE | SCHOOL | 18.23 | 17.41 | - 4.53% | 16.71 | - 3.97% | 16.57 | - .89% |
| 14 | EAST. CNTR | GLENDIVE | SCHOOL | 20.35 | 19.99 | - 1.79% | 20.24 | 1.28% | 20.29 | .22% |
| 15 | SWAN RIVER | SWAN LAKE | MISC. | 34.03 | 32.67 | - 3.99% | 36.95 | 13.10% | 37.44 | 1.33% |
| 16 | HM FR AGED | LEWISTOWN | APT CMPLX | 31.72 | 25.93 | -18.26% | 25.83 | - .41% | 27.13 | 5.04% |
| 17 | WRM SPRNGS | WARM SPRING | HOSPITAL | 40.49 | 35.41 | -12.54% | 36.16 | 2.13% | 38.46 | 6.35% |
| | AVERAGE | | | 27.44 | 23.92 | -12.84% | 25.24 | 5.52% | 23.97 | - 5.01% |

ENERGY USAGE LISTING FOR SCHOOL BUILDINGS
LISTED IN INCREASING PERCENT CHANGE FROM 1976

| O. | NAME | LOCATION | BUILDING TYPE | BTU/ GSF-DD 1974 | BTU/ GSF-DD 1975 | % CHANGE FROM 1974 | BTU/ GSF-DD 1976 | % CHANGE FROM 1975 | BTU/ GSF-DD 1977 | % CHANGE FROM 1976 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | DF & BLND | GREAT FALLS | SCHOOL | 20.04 | 16.98 | -15.29% | 18.61 | 9.60% | 15.91 | -14.49% |
| 2 | PINE HILLS | MILES CITY | SCHOOL | 28.94 | 27.45 | - 5.14% | 28.87 | 5.18% | 25.73 | -10.90% |
| 3 | U. OF M. | MISSOULA | SCHOOL | 22.05 | 18.78 | -14.82% | 19.22 | 2.36% | 17.19 | -10.58% |
| 4 | MT TECH | BUTTE | SCHOOL | 17.99 | 13.72 | -23.72% | 15.87 | 15.71% | 14.21 | -10.48% |
| 5 | W. M. C. | DILLON | SCHOOL | 20.00 | 18.36 | - 8.21% | 17.62 | - 4.05% | 16.39 | - 6.95% |
| 6 | MNT. VIEW | HELENA | SCHOOL | 19.06 | 16.21 | -14.93% | 18.08 | 11.51% | 17.11 | - 5.36% |
| 7 | M. S. U. | BOZEMAN | SCHOOL | 28.05 | 22.11 | -21.17% | 24.39 | 10.29% | 23.22 | - 4.80% |
| 8 | E. M. C. | BILLINGS | SCHOOL | 22.05 | 18.74 | -15.00% | 21.19 | 13.04% | 20.35 | - 3.95% |
| 9 | N. M. C. | HAVRE | SCHOOL | 18.23 | 17.41 | - 4.53% | 16.71 | - 3.97% | 16.57 | - .89% |
| 10 | EAST. CNTR | GLENDIVE | SCHOOL | 20.35 | 19.99 | - 1.79% | 20.24 | 1.28% | 20.29 | .22% |
| | AVERAGE | | | 23.95 | 19.95 | -16.71% | 21.42 | 7.39% | 20.03 | - 6.50% |

ENERGY USAGE LISTING FOR APT CMPLX BUILDINGS
LISTED IN INCREASING PERCENT CHANGE FROM 1976

| NO. | NAME | LOCATION | BUILDING TYPE | BTU/ GSF-DD 1974 | BTU/ GSF-DD 1975 | % CHANGE FROM 1974 | BTU/ GSF-DD 1976 | % CHANGE FROM 1975 | BTU/ GSF-DD 1977 | % CHANGE FROM 1976 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | VET. HOME | COLUMBIA FA | APT CMPLX | 31.37 | 26.88 | -14.30% | 27.72 | 3.14% | 27.46 | - .95% |
| 2 | HM FR AGED | LEWISTOWN | APT CMPLX | 31.72 | 25.93 | -18.26% | 25.83 | - .41% | 27.13 | 5.04% |
| | AVERAGE | | | 31.51 | 26.50 | -15.90% | 26.89 | 1.47% | 27.30 | 1.54% |

ENERGY USAGE LISTING FOR HOSPITAL BUILDINGS
LISTED IN INCREASING PERCENT CHANGE FROM 1976

| O. | NAME | LOCATION | BUILDING TYPE | BTU/ GSF-DD 1974 | BTU/ GSF-DD 1975 | % CHANGE FROM 1974 | BTU/ GSF-DD 1976 | % CHANGE FROM 1975 | BTU/ GSF-DD 1977 | % CHANGE FROM 1976 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | BLDR RIVER | BOULDER | HOSPITAL | 37.98 | 38.59 | 1.60% | 41.26 | 6.93% | 36.56 | -11.39% |
| 2 | GALEN | GALEN | HOSPITAL | 33.91 | 33.31 | - 1.75% | 35.01 | 5.09% | 31.68 | - 9.51% |
| 3 | WRM SPRNGS | WARM SPRING | HOSPITAL | 40.49 | 35.41 | -12.54% | 36.16 | 2.13% | 38.46 | 6.35% |
| | AVERAGE | | | 38.49 | 36.04 | - 6.37% | 37.53 | 4.14% | 36.58 | - 2.53% |

ENERGY USAGE LISTING FOR OFFICE BUILDINGS
LISTED IN INCREASING PERCENT CHANGE FROM 1976

| 'O. | NAME | LOCATION | BUILDING TYPE | BTU/ GSF-DD 1974 | BTU/ GSF-DD 1975 | % CHANGE FROM 1974 | BTU/ GSF-DD 1976 | % CHANGE FROM 1975 | BTU/ GSF-DD 1977 | % CHANGE FROM 1976 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | CAPITOL | HELENA | OFFICE | 17.76 | 15.35 | -13.55% | 16.72 | 8.89% | 12.99 | -22.30% |
| | | AVERAGE | | 17.76 | 15.35 | -13.55% | 16.72 | 8.89% | 12.99 | -22.30% |

ENERGY USAGE LISTING FOR MISC. BUILDINGS
LISTED IN INCREASING PERCENT CHANGE FROM 1976

| 'O. | NAME | LOCATION | BUILDING TYPE | BTU/ GSF-DD 1974 | BTU/ GSF-DD 1975 | % CHANGE FROM 1974 | BTU/ GSF-DD 1976 | % CHANGE FROM 1975 | BTU/ GSF-DD 1977 | % CHANGE FROM 1976 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | SWAN RIVER | SWAN LAKE | MISC. | 34.03 | 32.67 | - 3.99% | 36.95 | 13.10% | 37.44 | 1.33% |
| | AVERAGE | | | 34.03 | 32.67 | - 3.99% | 36.95 | 13.10% | 37.44 | 1.33% |